DOCUMENT RESUME

ED 044 789 EA 003 142

AUTHOR Knezevich, Stephen J., Ed.; Eye, Glen G., Ed.
TITLE Instructional Technology and the School Administrator. Final Report.
INSTITUTION American Association of School Administrators, Washington, D.C.
REPORT NO AASA-Tech Ser-3
PUB DATE 70
NOTE 143p.
AVAILABLE FROM American Association of School Administrators, 1201 Sixteenth Street, N.W., WASHINGTON,D.C. 20036 ($6.00, quantity discount)

EDRS PRICE EDRS Price MF-$0.75 HC Not Available from EDRS.
DESCRIPTORS *Administrative Personnel, Computer Assisted Instruction, Cost Effectiveness, Data Collection, Educational Finance, *Educational Innovation, Educational Television, *Electronic Equipment, Evaluation Criteria, Individualized Instruction, Information Networks, *Instructional Technology, Photography, Programed Instruction, *Systems Approach

ABSTRACT

A special committee on technology and instruction, appointed by the AASA in 1967, reviewed the literature on instructional technology and visited the experimental and developmental work being done in the area. This document presents the committee's report to the profession on the promises and immediate possibilities of the new technology. The contents focus on technology as a systematic approach to practical problems. Seven chapter incorporate a review of interesting and meaningful issues in instructonal technology, provide a description of its current status, identify recent and significant innovations in the teaching or learning process, examine the existing evidence based on research or experience that supports newly developed techniques and approaches to instruction, and appraise the validity of claims for instructional innovation. (Author/ML)

PROCESS WITH MICROFICHE
AND PUBLISHER'S PRICES.
MICROFICHE REPHODUCTION
ONLY.

Permission to reproduce this copyrighted work has been granted to the Educational Resources Information Center (ERIC) and to the organization operating under contract with the Office of Education to reproduce documents included in the ERIC system by means of microfiche only, but this right is not conferred to any users of the microfiche received from the ERIC Document Reproduction Service. Further reproduction of any part requires permission of the copyright owner.

Copyright © 1970

American Association of
School Administrators

Library of Congress
Catalog Card Number: 77-137215

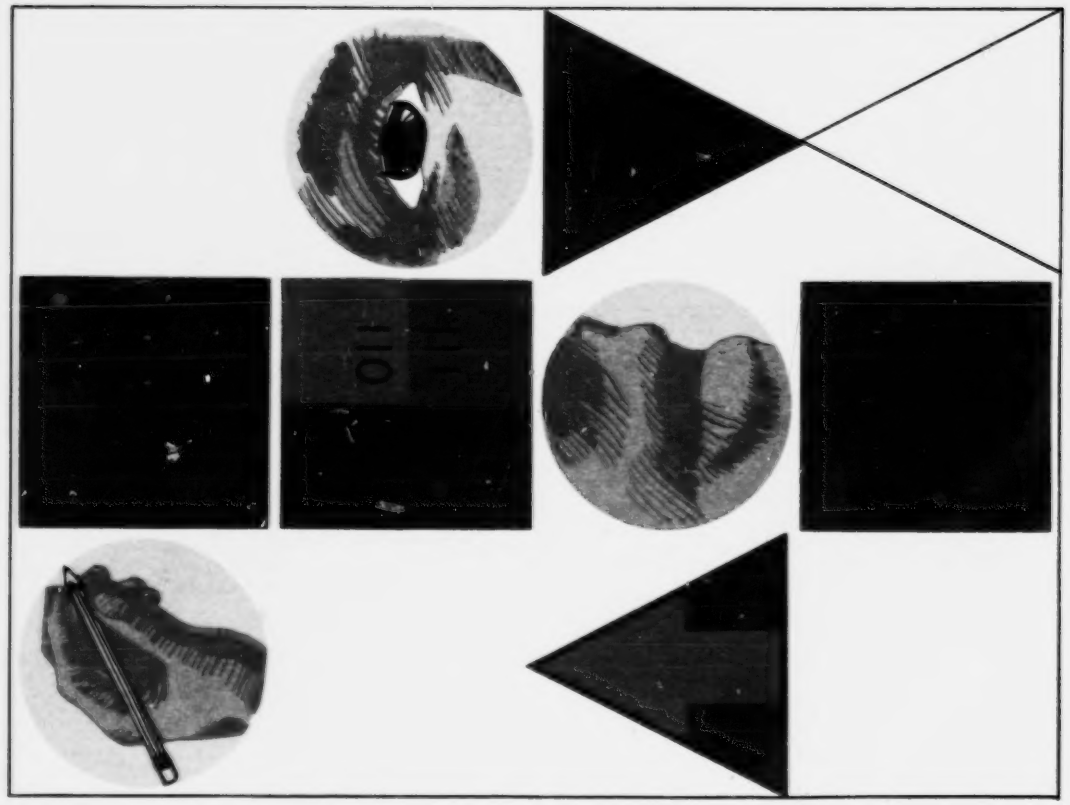
All rights reserved. No part of this
document may be reproduced in any
form without permission in writing
from the publisher.

Single copy, $6
2-9 copies, 10 percent discount
10 or more copies, 20 percent discount

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

Instructional Technology and the School Administrator



EA 003 142

ED044789

Instructional Technology and the School Administrator

Prepared by the AASA Committee
on Technology and Instruction

Edited by Stephen J. Knezevich,
AASA Associate Secretary
and Glen G. Eye,
Professor, University of Wisconsin

Published by the American Association of School Administrators

AASA Officers

President
Harold H. Eibling, *Superintendent of Schools,* Columbus, Ohio

Vice-President
H. Vaughn Phelps, *Superintendent,* Westside Community Schools, Omaha, Nebraska

President-Elect
John B. Geissinger, *Superintendent of Schools,* Tenafly, New Jersey

Past-President
Arnold Salisbury, *Chairman,* Department of Educational Administration, Western Illinois University, Macomb

Executive Committee
J. A. Kinder, *Superintendent of Schools,* Rochester, Minnesota
Dana P. Whitmer, *Superintendent of Schools,* Pontiac, Michigan
Frank Dick, *Superintendent of Schools,* Toledo, Ohio
Norman B. Scharer, *Superintendent of Schools,* Santa Barbara, California
Albert L. Ayars, *Superintendent of Schools,* Spokane, Washington
Floyd W. Parsons, *Superintendent of Schools,* Little Rock, Arkansas
The President, President-Elect, Vice-President, Immediate Past President, and Executive Secretary, ex officio

AASA Staff

1201 Sixteenth Street, N.W., Washington, D.C.

Executive Secretary
Forrest E. Conner

Secretary Emeritus
Finis E. Engleman

Deputy Executive Secretary
William J. Ellena

Associate Secretaries
Robert M. Isenberg
James R. Kirkpatrick
Stephen J. Knezevich
George B. Redfern
John Wilcox

Director, AASA-NASE
Stephen J. Knezevich

Associate Director, AASA-NASE
Richard G. Morrow

The AASA Committee on Technology and Instruction

Glen G. Eye, *Cochairman*
Professor, University of Wisconsin, Madison

Stephen J. Knezevich, *Cochairman*
Associate Secretary
American Association of School Administrators
Washington, D.C.

Martin B. Garrison
President, Henderson College, Arkadelphia, Arkansas

Angelo Giaudrone
Superintendent, Tacoma, Washington

Wilma L. Victor
Superintendent, Intermountain School
Brigham City, Utah

D. Richard Wynn
Chairman, Department of Educational Administration
University of Pittsburgh, Pennsylvania

Contents

Foreword by Forrest E. Conner

1. Technology and Instruction: Some Basic Perspectives 12
2. Typology of Instructional Technology 31
3. The Computer and Instruction: The Promise of an Advanced Technology 50
4. Instructional Technology: Learning Impacts and Bypasses 70
5. The Administrator and Instructional Technology: What Questions Should Be Asked? 92
6. Redefinition of Education-Industry Relationships 112
7. Instructional Technology Reshapes the School: Its Impact on Faculty and Administrators 131

Foreword

Expectations for the superintendency are many and varied. He is asked to be an educational and community leader, a decision maker, a planner, and an efficient manager of the resources of the school district. These and other roles must be fulfilled in a climate of uncertainty generated by incomplete information on matters of importance and pressures produced by social revolution and conflict. Decisions made about the use of new technology in an atmosphere of conflicting claims and limited experience illustrate one of the challenges confronting the school executive.

People request more of education today than at any other time in history. New demands are placed at the doorsteps of schools. These rising expectations should not obscure the importance of learning in the educational institution. Learning is what schools are all about. It has been and undoubtedly will be a matter of preeminent concern among all school administrators. Recognizing this, while at the same time sensing the confusion and conflicting interpretations of the contributions of technology to the improvement of learning and instruction, the American Association of School Administrators created in 1967 a special Committee on Technology and Instruction. The Committee was charged with the responsibility of reviewing the literature on instructional technology, visiting the experimental and developmental work being done in the area, and preparing a report to the profession on the promises and the immediate possibilities of the new technology. This relatively small group of practicing administrators and professors is now ready to report.

The AASA is indebted to these men and women for the time

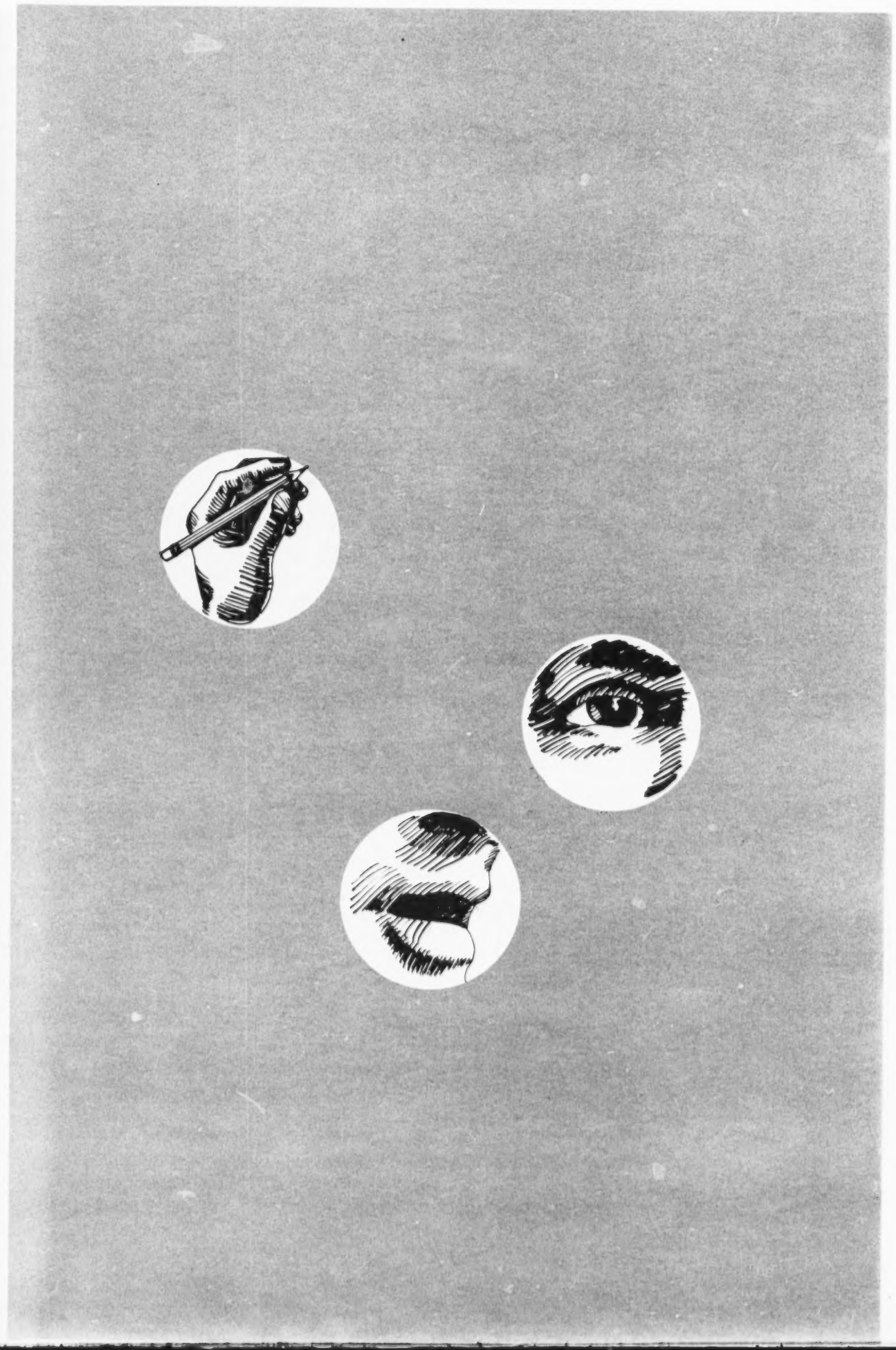
and effort dedicated to a difficult task. The responsibilities were executed with distinction and within a relatively short period of time. As is usually the case when exploring new movements, the Committee found relatively few benchmarks or definitive guides to direct its efforts.

Optimists and pessimists can be found in all walks of life on almost any issue. This AASA Committee recognized that a polarization of viewpoints with respect to instructional technology was evident in the literature and in the conversations with leaders in the field. The Committee avoided serving a narrow segment or a single point of view. It concerned itself instead with the development of a perspective that could be useful to administrators confronted with making difficult choices in the field of instructional technology.

What follows is a review of a most interesting and meaningful set of issues in instructional technology and a description of its status at this point in time. The Committee identifies within its report the recent and significant innovations in the teaching or learning process, examines the existing evidence based on research or experience which supports newly developed techniques and approaches to instruction, and appraises the validity of claims for instructional innovations. It can be said that the AASA Committee counted the early returns and told it like it is. The realities confronting school administrators demand nothing less. Perhaps some would have preferred that the Committee champion a given point of view without regard to facts or realities, but this was not done.

This is the third and the last of the technology series prepared by the American Association of School Administrators. Reports on *EDP and the School Administrator* as well as the more recent one on *Administrative Technology* preceded this final and most significant study on instructional technology and the school administrator. It is written to provide the kinds of information and perspectives that administrators need to fulfill their leadership functions in curriculum and instruction as well as to better meet their responsibilities as decision makers who must allocate the all too scarce resources within an educational system to the many and varied goals of education.

Forrest E. Conner
Executive Secretary, AASA



1. Technology and Instruction: Some Basic Perspectives

Man has focused from the earliest days to the present on how to maximize his efforts to obtain the highest yields from his labors. Some spectacular successes have been registered by applying the creative mind to vexing problems. The result often has been the production of inventions to relieve, to some extent, menial, monotonous, and back-breaking labor. This, in turn, has allowed civilized man to extend his range of endeavors and to enlarge his quest for what is called a better living. From the backs of men to the backs of beasts, to machines, to automated machines, to total cybernation, the direction has been certain.

Man has only gradually increased his precious time until recently to do any but essential labor. In every century but our present one, productivity increased rather slowly, with long plateaus before the next jump upward. The gradualism of change in the past seldom generated serious problems of social adjustment. This is in sharp contrast with the position we find ourselves in today as a result of the rapidly emerging new technologies of the last two decades. The impact of the quickening pace on human and social institutions has pushed or strained some to apparent breaking points. Man has been alternately amazed and bewildered, pleased and perplexed, impressed and frustrated by recent events. Whatever its consequences, however, rapidly developing technology is a fact of life in the twentieth century.

Technology contributes more to mankind than relief from the physical discomforts of work. It entertains. It speeds communication. It performs mathematical operations with amazing speed. It increases the possibility of learning some things better and

faster. It is with the contribution of technology to human learning that this volume is concerned.

More and more people consider the new technology of the last two decades as a promising source of help for the improvement of school operations. Other volumes published by AASA describe the impact of technology on the administrative process and procedures. This publication is addressed to school administrators and their constant search for ways of enhancing learning opportunities and effectiveness.

A definitive statement on how the new technology will influence instruction may not be available for at least another decade. This publication is merely an initial probe, the counting of the early returns on the issue, not the final assessment. As the federal Commission on Instructional Technology puts it: "Examining the impact of technology on American education in 1969 is like examining the impact of the automobile on America when the Model T Ford first came on the market." [1]

The enterprise is confronted by forces other than those represented by technology. New technology is only one change among many that must be assimilated. The problems of change may be made more difficult by the type of organization or structure of the institution. Institutions are designed, in the first instance, to ensure stability of operations; this sometimes means stability at the expense of facilitating change and adjustment. Educational institutions are not alone in facing this dilemma; government and religious organizations are geared to preserve previous standards and goals with certain organizational processes and expectations. The individuals who comprise these organizations' working parts are expected to function in specified ways.

New technologies consume resources in their development stage as well as during the subsequent implementation phase. Sizable investments of time and money are necessary to build a broad base of technological capital for American education. Some argue that insofar as instructional practices are concerned, education is in the "cottage industry" or pre-Industrial Revolution stage of development. The problems confronting education as it seeks to adapt the technological wonders of the twentieth century are not unlike those facing underdeveloped nations desiring to establish a modern way of life. Often the personnel are not ready to use the new technology wisely and well, nor are the new technologies readily adaptable to the unique challenges of the new situation. Perhaps this argument is an exaggeration to prove a point insofar as education is concerned.

Within the last two decades education has started to demonstrate a lively concern for investments in developing and implementing new technologies. State and local funds allocated

to such purposes, however, are meager in amount and are confined to a relatively few districts. This study confirms what other writers have observed: namely, that most of the funds for expanding and implementing instructional technology in education have come from federal sources. For example, at least a substantial part of the cost of almost all the foreign language laboratories installed in public schools since 1958 was paid with federal money.

Economic factors, often overlooked, influence the rate of innovation in school systems with barely enough resources to keep ongoing programs operating. Public demand for implementation of new instructional technologies is not always followed by increased financial support for such endeavors. State and local governments often do not value technology sufficiently, as yet, to provide the financial support to match the popular demands for greater use of technology in the schools. There is little point in advocating innovations if one is unwilling to pay the price that is inevitably attached to all such endeavors. This AASA Committee concurs with the spirit of the recommendation of the federal Commission on Instructional Technology, which declared: "In the conviction that technology can make education more productive, individual, and powerful, make learning more immediate, give instruction a more scientific base, and make access to education more equal, the Commission concluded that the nation should increase its investment in instructional technology. . . ." [2]

The Dilemmas of Technology

The great breakthroughs in science and technology are documented by many writers. No other nation has come close to matching the awesome economic and technological development recorded to date in America. From these breakthroughs have come an unusually high degree of economic freedom, an unusually high level of productivity. These developments were nurtured by American democratic traditions and a system of public education.

America now finds itself confronted by a peculiar dilemma. The advanced technology, which our concern for human values has furthered, now threatens those very values. For example, technology often requires the surrender of varying degrees of individuality; everyone appears to be reduced to a common denominator for the data-processing function of computers. This has led to feelings of depersonalization. Moreover, the phenomenal efficiency of computers has led many to fear that their jobs will be usurped by computers. Often it appears that we must order our lives to serve the interests of technology, rather than ordering technology to serve our interests. Yet it was our respect for individuality as a value that led America to

establish universal public education and to encourage divergent thinking, both of which were essential to the development of advanced technology.

The greatest advancements in the implementation of science and technology have been in the more material aspects of society. Little has been done to extend our capacity to cope effectively with the human and social problems that technology has generated. "Progress" (technological and otherwise) is dedicated ostensibly to easing man's burden. In the case of technology, it has eased one burden only to impose others.

Admiral Hyman Rickover declared that technology should not be considered "an irrepressible force of nature to which we must meekly submit." Technology exacts a price for its blessings. It is not always a positive force. It is a *means,* capable of control by man, and not an *end.* Again, as Rickover put it, technology is not "infallibly beneficial" but can do harm, particularly if used without thought for its possible consequences. Technology gives man enormous power to injure his fellow man, pollute the environment, and upset social relationships. Rickover argued that technology should be "humanistic," made to adapt "to human interests, needs, values and principles." In summary: technology can have no legitimate purpose but to serve man—man in general, not merely some men. It must serve future generations, not merely those who currently wish to gain advantage for themselves. It must serve man in the totality of his humanity, encompassing all his manifold interests and needs, not merely some one particular concern of his.[3] It is equally naive to make technology the scapegoat for the many human failings of greed, avarice, blindness, cruelty, and sinful pride.

This volume has an underlying premise, the view that technology can "be made to produce maximum benefit and do minimum harm to human beings and to the values that make for civilized living." Technology can be used to effect greater humanization of education. It should not be assumed that the availability of a given set of machinery will facilitate this goal. There is in some quarters a kind of technocratic arrogance that suggests infallibility for technology. It can reasonably be assumed, however, that the machinery which technology provides education can be an effective *means* for accomplishing more quickly some of the objectives that have long been expressed and sought.

Educators must think positively about technology as a new approach to meet the child in his own arena each day. Education, of all man's many social institutions, appears to be in the best position to promote better living through technology. The nature of education is such that it is highly directed toward process and change. The educator is presumed to have the

capabilities and interest to move more effectively and decisively into this area of thought and action. The other side of the coin must not be ignored. There is the danger of technological pollution in education resulting from the flood of highly touted artifacts of instruction with relatively low performance capabilities. Again, may it be said that technology must be viewed as a means to improve rather than to enslave education.

Technology and Instructional Technology Defined

The dictionary and many writers tend to assign three meanings to the word *technology,* which comes from the Greek for "systematic treatment." Technology may be viewed as (1) "terminology of a particular subject," that is, technical language; (2) "the science of the application of knowledge to practical purposes," that is, applied science; or (3) "the application of scientific knowledge to the practical purposes in a particular field." [4] Some point out that it is a way of ordering the possessions of the mind.

Technology emphasizes the practical. However, *technology* may also be just another name for a new product, hardware, or equipment. For example, some tend to equate audiovisual instruction aids such as films, overhead projectors, and television receivers with instructional technology. Much of the writing in instructional technology focuses on a unique physical or social invention that has been or could be adapted to instructional purposes. Physical inventions include television and computers that have been adapted for use in instruction. Examples of a social invention are programed instruction and systems analysis. The latter suggests a "machineless technology." As a matter of fact, it can be said that the machines would have little if anything to say without programed instruction or other so-called software.

This report rejects the narrow conception of technology as a cluster of machines and declares that instructional technology is a way of thinking that may or may not include a physical invention or machine. Corey viewed instruction as "the process whereby the environment of the individual is deliberately manipulated to enable him to learn to emit or engage in specified behaviors under specified conditions or as responses to specified situations." [5] Combining this concept with that of technology we arrive at a conceptualization of instructional technology as an effort with or without machines, available or utilized, to manipulate the environment of individuals in the hope of generating a change in behavior or other learning outcome. As such, technology is a means or a tool for accomplishing educational purposes. A technology that can be adapted to the purposes of instruction is worthy of implementation if it can generate desired learning outcomes in a shorter time period, with the probability

of fewer undesirable side effects, and more economically than alternative or competing technologies.

Referring once again to the related federal Commission, instructional technology was defined as "the media born of the communications revolution which can be used for instructional purposes" in one sense and as "a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of objectives, based on research in human learning and communication, and employing a combination of human and non-human resources to bring about more effective instruction." [6]

Rickover stressed that science should not be confused with technology. Science dwells on "discovering true facts and relationships of observable phenomenon in nature, and with establishing theories that serve to organize masses of verified data concerning those facts and relationships." [7] In contrast, he declared that "technology cannot claim the authority of science" for technology deals with "tools, techniques, procedures: the artifacts and processes fashioned by modern industrial man to increase his powers of mind and body." He then added that the "methods of science require rigorous exclusion of the human factor," for "the searcher for truth cannot pay attention to his own or other people's likes and dislikes, or to popular ideas of the fitness of things." On the other hand, since "technology is action" rather than the pure thought that is science, technology may be potentially dangerous if it is allowed to disregard human considerations.

A sense of urgency pervades the various publications that stress the need to make better use of the new physical and social inventions in education. In a broad sense, the adaptation of a new invention to educational purposes can be construed as the "application of scientific knowledge to the practical purposes of education." It would be more precise to say that there are many new and old inventions (which trace their origins to scientific knowledge) that could help to improve various aspects of education.

The tasks of the AASA Committee on Technology and Instruction were to identify such inventions, to determine which could contribute to the improvement of instruction, to ascertain what should be done to adapt inventions to instructional purposes, and to recognize what adjustments in educational resources (human as well as fiscal) are necessary to make the inventions practical.

Certain connotations appear to accompany the term *technology*. More often than not, technology suggests a better way of doing things or, in the case of education, individualization of instruction. Much that is "good" is associated with technology. To argue that education should adopt quickly what is

loosely defined as "modern technology" is to believe that any and all technologies are good and deserve consideration in education. Quite often those who most vigorously advocate the adoption of a particular technology are not those who must live with the decision. Inventors and promoters frequently get carried away with their enthusiasm and have little patience with the hesitancy of decision makers who run real risks. It is the decision maker, not the inventor or promoter, who will suffer for an unwise decision. Hence, the decision maker must take a cold, realistic look at the sometimes exaggerated claims of promoters.

There are other negative dimensions as well, such as the fear and concern generated by the changes inherent in taking advantage of a new approach. A new invention or new way of doing things may upset existing sensitive balances—balances in social relationships among professionals or between man and his environment. It is upsetting to many to alter established patterns of teaching behavior to accommodate a new technological development. In other words, social costs and dislocations often accompany change based on the end product of technology. The implication is clear. People as well as the invention and the content of the educational experience will have to be modified to take advantage of the technological development.

Applications to Education

One often hears the query: Why don't educators take advantage of technology? This question implies that schools through the ages have remained insulated and isolated from advances in science and technology. There is little to support this implication. The reverse is closer to the truth: technology always has and always will influence instruction, organization, and administration of education. The full impact may take longer than some feel it should. Perhaps it would be more accurate to phrase the question this way: Why can't educators move more quickly to adapt the new technology to the persistent problems in learning and instruction? The present era sees the generation of an endless variety of machines and systems not specifically designed for education. Added to this are demands on every side for innovations in education.

To set the record straight, schools *have* changed throughout the ages and the new technologies of the past have significantly modified the manner in which the learner learns and the teacher teaches. It is well to examine the impact of some old and widely accepted technologies. The development of the alphabet and writing 5,000 years ago was the beginning of many dramatic innovations that were destined to influence learning and the purposes and means of instruction in a profound manner. This first and basic technological breakthrough in intellectual means

for expressing, recording, and preserving the knowledge of mankind serves to illustrate the fact that an invention of great significance may not be a piece of hardware; it can be a system or an approach. Similarly, significant improvements in auxiliary devices—that is, factors that may increase the effectiveness of a new system or invention without changing its basic character—are registered as breakthroughs. To illustrate, the invention of paper and the perfection of writing instruments reinforced and made more practical the process of recording information with alphabetical symbols. A system of writing gave birth to what is now called a book. By adapting the technological jargon of our day, the historically important instructional artifact known as a book can be given new importance if defined as "a series of paper-based levers of varying sizes which can be bound together, within a hard or soft cover, and organized for the purpose of presenting information in a sequential manner." In short, the book can be viewed from its mechanical aspects as separate from its substantive content. Television and the computer are seen, more often than not, as mechanical, electronic, or optical gadgets. The book is seldom seen in the same light.

These early wonders called the alphabet, paper, and book survived the centuries-long test of time, in spite of their numerous limitations. A primary limitation was that they tended to involve only a few of man's sensory apparatuses in the learning process. There was a limited interaction among the senses, which can be interpreted as the input devices by which man learns. In the case of writing, there was an additional "technological" problem: the process of producing handwritten works was very slow and expensive. Few could own books. Until very recently literacy for all was rarely advocated and from a practical standpoint was impossible to achieve. Something new had to happen before the written word would be within the reach of large numbers of people. The "something new" was the invention of movable type by Gutenberg. Gutenberg's idea was to serve as the basis for the "writing machine" or printing press. The production of printed books far outstripped the laborious handwritten system. The great cultural heritage could now be transmitted to more people with greater ease. The first practical mass media could be established.

Printed books changed the instructional process from being exclusively one in which those without a book listened passively to the one person who owned the handwritten book. (The lecture approach to instruction survives nonetheless.) Printing made it possible to shift the instructional mode from a purely oral to a visual *and* oral presentation.

Gutenberg deserves credit for generating one of the great technological marvels of all times. Printing was, of course, an

extension of the earlier development of the alphabet and paper. However, the new element, the movable type, opened doors never previously dreamed of. A later adaptation of movable type was the invention of the typewriter, which greatly speeded up the dissemination of ideas. So powerful is the technology based on printing that few can imagine an educational system without it. Many, in fact, equate the reading of classical writing with an education.

There were other ideas of importance—but none as far-reaching as the alphabet, paper, and printing—that altered instructional approaches. About a hundred years ago, the innovative schools were those employing maps, globes, and charts in addition to the printed text for stimulating pupil learning. Josiah Bumstead, almost a century ago, claimed that the inventor of the blackboard "system" deserved to be ranked among the great contributors to learning and science; indeed, that he was among the greatest benefactors of mankind. Such enthusiasm has been tempered, but the particular qualities of blackboards —flexibility, ease of use, and inexpensiveness—suggest their continued use along with all the sophisticated gear of this era.

Anderson traced the history of technology in American education from 1650 to 1900.[8] He labeled the colonial period as "the pre-industrial era in technology" where all work was done by hand. The colonial schools had no blackboards, slates, or maps. Only a few could boast of a globe. Quills, ink, and paper were crude and expensive but the only instructional appartus available. The hornbook, a single page of information fastened to a board and covered with a thin sheet of horn, was the closest approximation to a textbook. It was in the first half of the 1800's that blackboards, maps, globes, and some demonstration apparatus began to appear in fairly large numbers in the schools. Although the "magic lantern" and stereoscope began to be talked about in the late 1800's, Anderson concluded: "Thus, with the advantage of historical hindsight, we can safely observe that technology from the colonial period to 1900 made very few inroads into the field of education. The real revolution was yet to come." [9] The changes in instruction and equipment in the twentieth century proceeded at a very rapid rate, but evidently not fast enough to satisfy the critics.

Of more recent vintage is the technology that produced the internal combustion engine. The engine made automobiles and school buses practical and dependable means of transportation. The school bus in turn influenced the way pupils were organized for learning even in the most isolated of rural areas. It can be said that the internal combustion engine was a powerful force in stimulating school district reorganization which, in turn, influenced the instructional process.

The foregoing examples serve to illustrate the point that no

single technological development stands alone. Thus, the alphabet required paper and writing or printing devices. School district reorganization had to wait for the invention of an effective transportation system which included improved roads as well as buses. One of the limitations on the speed with which technological developments can be adapted to schools is the speed with which the total system is changed.

The present desire for increasing the pace of change is related to the speedup in the introduction of new inventions and approaches with promise for the improvement of education. To some, these new developments will bring an end to the so-called Gutenberg Age, which gave the printed book a dominant role in the instructional process. For more than 50 years inventors like Thomas Edison have been proclaiming that printed books are obsolete and that other means are more efficient in promoting learning. This may be true, but there are many who resist the idea. Resistance is not a new response; it has occurred through the ages. Sometimes it is unreasonable and at other times it is based on the fact that the introduction of a new technology too soon (that is, before it is ready) may create a backlash which in the long run will militate against realization of its full potential.

School Organization as a Type of Technology

Much of this publication will be focused on the new devices or physical inventions popularly considered as technology. In previous years, the main thrust for improving learning emphasized the arrangements of pupils within classes or schools. It may be well to examine this "educational technology" of yesterday before proceeding to a review of present interpretations of technology. It can be called a type of technology if the broad definition of the term as a systematic approach to practical problems is accepted.

The ways of organizing students or plans for presenting instructional materials (with or without the use of machines of varying degrees of sophistication) may be considered a rudimentary type of intellectual technology. Many ways of organizing pupils, of sequencing instructional experiences, and of deploying teachers in the schools have been attempted over the last century. Many were abandoned after a brief trial despite great expectations of success before the fact. Most such schemes focused on instructional organization patterns.

The new technology of systems which focuses on various patterns of organization is concerned primarily with form or structure of operations. The purpose in organizing in the first instance is to design a systematic means of differentiating and coordinating human and material resources to attain objectives. The objective of any scheme of instructional organization would

be to differentiate and coordinate time, personnel, and resources available to schools to maximize learning opportunities for all students. The fundamental value of a given pattern must be judged in terms of its capability to maximize learning opportunities and experiences and to minimize expenditure of resources without reducing learning effectiveness. Organization can be viewed as a technological tool in the process of education, a vehicle for replacing chaos and confusion with system and order to foster learning. A given pattern of organization represents potential; that is, it may hold the promise of achieving certain objectives, but it carries no guarantee.

Part of the problem in attempting to utilize the technology of organizational arrangements in education can be traced to the fact that it is only one among several variables which can influence the complex process of learning. There is no well-designed and carefully executed research to demonstrate to what degree a single known variable, such as instructional organization, can alter the amount learned by a pupil or increase the performance levels of a teacher. How the instructional organization factor affects pupil learning is not known. Other factors in the learning process—the pupil's ability, interests, socioeconomic background, motivation (personal or that attributable to the value attached to education by his parents); the teacher's preparation, attitudes toward particular groups of pupils, knowledge of subject matter, skills in using particular instructional devices; the availability of instructional materials and equipments; and the skills being learned—may have a greater or lesser impact. The number of known and unknown variables related to and influencing the very complex process of learning is sizable indeed.

What is it that teachers can or cannot do to foster specified learning outcomes in one type of instructional organization in contrast to another? This is a significant question for those who hold the power to make decisions on changes. The avid proponents of one instructional organization pattern, as opposed to another, present claims that often must be accepted on faith; these proponents substitute crusading zeal for hard data. The history of structuring school operations to maximize learning is replete with examples of bright promises of success tarnishing when tested in the harsh light of reality.

By no stretch of the imagination can the present period be considered unique in expressing concern for new ways of organizing pupils within instructional centers or within a given age or class grouping to facilitate learning. Various editions of the *Encyclopedia of Educational Research* record the long story of "organizational technology" that had its beginnings about the middle of the nineteenth century. The avowed mission of the movement, which continued into the twentieth century, was to

overcome rigidity of existing instructional approaches and to make learning more relevant, meaningful, and efficient.

It may be appropriate here to repeat that technology is concerned with means, not with ends. There is less conflict with reference to educational goals. To illustrate, everyone agrees that improvement of instruction is a worthy goal. No one disagrees with the following dicta of our educational heritage: *Individualize instruction. Enrich learning. Adapt materials to individual differences among slow and fast learners. Allow each child to progress at his own pace. Seek to foster continuous growth. Teach them to learn to think. Emphasize problem solving rather than accumulation of bits and facts. Provide for effective social personal development. Educate the whole child. Meet the needs of the individual and society.*

These phrases, which carry a favorable connotation, have been repeated by thousands over an extended period of time. And no present-day educator can honestly claim to be the originator of any of the notions inherent in the above-listed terms. No one can claim that his post-World War II pattern for instructional organization, or for that matter any other technology, initiated concern for "individualizing instruction," "allowing each child to progress at his own speed," or "learning to think." The issue is whether the proposed technology happens to be the optimum *means* for achieving the goals everyone agrees on.

This general background on organization, goals, and means is necessary before attempting to interpret specifics. History may document when a given mode of organization was adopted. It does not document when that organization was discontinued in favor of other practices. The fact that a new approach falls by the wayside may not be the result of innate resistance to change or a battle with the traditionalists, but of the inability of that approach to substantiate prior claims for improvement.

It is well to recognize the constraints faced by those who would generate unique instructional organization patterns. There are now over 52 million public and private elementary and secondary school pupils to be educated. It is questionable whether anyone can honestly promote the tutorial approach to instruction—namely, one teacher for one pupil—when confronted with the large numbers enrolled in public schools. In addition, the schools do not have access to unlimited resources. Grouping of pupils for learning is the only feasible approach in a nation committed to education for all.

Grouping means the establishment of some kind of classification scheme. In every pattern of instructional organization there must be some criteria for determining which pupils of what level of maturity should be assigned to what learning activities or what group of teachers. There is the additional problem of measuring pupil growth in learning and determining at

what point a pupil should be transferred to other teachers with different sets of specializations. This is a problem when a learner is initially admitted to school and continues until he is judged to have completed the formal program. Other criteria are necessary for determining what types of pupils shall be assigned to study together in what types of instructional centers and how these instructional centers shall be related to produce a unified and interrelated educational system.

The technology that sought to establish new instructional organizations was stimulated by the complexity of schools. There was little concern when there was only one school plant in a district. Similarly, in the days of the one-room–one-teacher school all pupils were assigned to a single teacher. The one teacher with many pupils in an ungraded one-room school would have been doomed to failure if the pioneer culture had demanded a comprehensive series of educational experiences for all. Some semblance of success was approximated because the curriculum was simple and educational objectives were limited.

About the time of the Civil War the graded school organization was introduced in this nation. It was heralded as one of the most significant instructional innovations in all of American education. The innovative schools of about 100 years ago were those which adopted the graded organization. Elementary schools so organized were so proud of the fact that they became known as "grade" schools. The traditional, hidebound, noninnovative, laggard schools were the ungraded or nongraded ones. The reverse appears to be promoted by some today. Thus, yesterday's innovation may become tomorrow's abomination. The change from nongraded to graded and then back to nongraded schools is finding its counterpart in movements to redistribute teaching efforts through differentiated assignments.

It wasn't long after introduction of the graded pattern, as early as the latter part of the last century, that some educators proposed necessary modifications in graded schools. Grades began to be interpreted as fixed norms; all pupils at a given level were required to acquire a specific quantity of subject matter before moving up the next step of the ladder. A significant amount of nonpromotion (pupil failure) was the inevitable result. More often than not, repeating a grade was a form of social punishment rather than an extension and improvement in learning experiences or compensatory opportunities. The rigidity, arising from misinterpretation of the grade concept, produced the undesirable lock-step approach which at present is rightfully severely criticized.

A series of proposals which can be described as a type of "educational technology" was designed in the late 1800's

to correct inflexible operation of the graded school. Most were identified with the particular school system in which they were developed. Among the more famous early efforts concerned with correcting abuses in the graded approach were the St. Louis, Pueblo, Cambridge, Portland, Batavia, North Denver, Santa Barbara, and Winnetka school organizational plans. These technological developments *did not* seek to eliminate grading as a practice or a name. The St. Louis approach, started in 1868, sought to ameliorate grade rigidity by classifying students at six-week intervals. The Pueblo plan, which continued in effect from 1888 to 1894, placed all children in grade units, but each child was permitted to progress through each unit at his own rate. The Gary plan was related to the original platoon school. It was a refinement of what Superintendent Wirt first tried in Bluffton, Indiana, in 1900. The Winnetka plan of 1919 was based on enrichment opportunities in addition to commonly accepted elementary school studies. Here, too, pupils were allowed to progress at individual and standardized rates. Burke's individual approach of 1913 represented one of the earlier efforts to permit individual rates of progress in promotion. The Dalton contract system of 1919 was a series of well-organized individual pupil job sheets or units. The technique permitted the student to move to another contract upon completion of requirements based on his own rate of learning. The Contract plan ran into difficulties related to keeping track of a room full of pupils, few of whom were at the same point. There are at present variations of the "learning contract" idea of allowing each pupil to complete a unit at his own rate. Individualization is in terms of pacing rather than pursuing different interests. Currently, teacher aides, with or without the assistance of a computer, can help the teacher evaluate pupil performance and keep track of progress. These approaches overcome the learning management problems that led to the demise of the Dalton plan. Individually Prescribed Instruction (IPI) has broken through the restrictions noted in earlier plans and has introduced new emphasis on the rearrangement of substance in learning experiences along with a more precise statement of learning objectives. Project Plan is another illustration of a modern approach to individualized pacing and delineation of objectives stated in behavioral terms.

The Cooperative Group plan of 1930 was perhaps a forerunner of the team teaching approach. It provided for a group of teachers to work together, each offering one part of the curriculum but all trying to coordinate efforts. In summary, some 50 years prior to present efforts there were attempts to develop an "educational technology" based on organizational arrangements to recognize individual differences, to express concern for continuous progress, to individualize instruction, and to en-

rich learning experiences. Some concentrated on the gifted and others worked with pupils within the entire range of the ability spectrum.

Post-World War II efforts, specifically the nongraded movement, trace their origins to Western Springs, Illinois, in 1936 or to the Maryland Avenue Elementary School in Milwaukee in 1942. Goodlad and Anderson did much to stimulate the development of the nongraded instructional pattern for elementary schools.

It is extremely difficult to find a standard definition for the so-called nongraded or ungraded school. The grades involved and even the name of the organizational scheme may not be the same in all places. The common bond among adherents of nongraded school ideas is reaction to the rigidity characteristic of graded structural patterns wherever found. The vague definitions of nongradedness and the lack of uniformity in its basic elements make it difficult to ascertain when a school becomes or does not become a nongraded institution.

To some, the nongraded organizational pattern is another name for a continuous promotion or no-failure policy. Since promotion implies that a child has learned a given amount within a specified period of time, be it a semester or a school year (10 months), and failure suggests the pupil has not learned the standard amount for the given period of time, there can be no promotion and failure per se if no time limit or constraint is placed on learning a given amount or acquiring a specific series of skills. At some point, however, those who require five years to learn to read and cipher as well as others who started at the same time but acquired the same level of reading and ciphering in two or three years must be separated in different learning situations lest one impede the progress of the other.

Research on advantages of the nongraded *vs.* the graded school approach to instructional organization is neither voluminous nor conclusive. Some researchers favor the nongraded approach, whereas others attribute advantages to the graded structural pattern.

The development of films during the 1940's represented a new technology aimed at improving the effectiveness of learning. It switched the emphasis from organization per se to the physical invention. Films had their greatest impact in dealing with highly specific skills, but for some reason they didn't quite live up to their potential. The emphasis on the medium rather than the content led some to believe that simply by showing films they were demonstrating innovativeness. At one time, the film was considered to be a replacement for the classroom teacher. But this view no longer prevails; most recognize it as a supplement rather than as a replacement.

Educational television placed greater emphasis on electronic

devices and transmitting information and images to the learner. The bold experiment of airborne television, supported by considerable foundation funds, only recently was brought to an end. The potential of educational television, one of the brilliantly acclaimed post-World War II plans, has yet to be realized. By the same token, it has not been abandoned. More ETV stations are being installed. The use of ETV continues to spread, albeit slowly, and perhaps soon there will be a resurgence of interest in this approach to instruction.

During the 1920's and 1930's, Morrison spoke of large-group and small-group instructional approaches. The late 1950's and 1960's saw a revival of a modification of this approach. It is related to the popular large-lecture approach found in universities. Lectures to large groups were followed by so-called small-group or "quiz" or "buzz" sessions for discussion. In universities, direction of the small groups is in the hands of student assistants rather than regular teachers.

Technological Potentials for Instruction

Technology can contribute many things to the instructional process. Some claim it can replace teachers. This usually doesn't mean all teachers. Few are able to spell out precisely how many teachers might be replaced or what types of persons in the instructional process may be done away with. Technology may improve teacher effectiveness—particularly in the presentation of content or the sensing of how to present ideas more effectively to a particular audience of students.

Technology may force reexamination of goals. This reexamination can at the same time refocus attention on the processes of goal attainment and the evidence of goal realization. Technology is one force stimulating concern for the development of performance objectives.

Technology may automate learning with development of a more orderly sequence for the elements of work. It also may help teachers diagnose learning difficulties more quickly. There may be some pupils who are reached better through the new media than simply through existing printed textbooks. Machines are far more patient in presenting concepts over and over again to the slow learner than are teachers.

Technology may help to individualize some types of learning. This is true if individualization is interpreted as individual pacing. Technology may enrich programs in small schools which find it economically impossible to offer comprehensive programs or to have the same quality of teachers in all programs.

Technology may do certain things which are not possible in any other way. Simulation and gaming of learning situations represent new developments made possible by computer technology. Technology may provide for self-instruction in out-of-

school situations for dropouts and adults. Educational television is a case in point.

Technology may strengthen research by enabling researchers to perform a whole series of computations that could be done no other way. It could improve the curriculum by closing the gap between students, teachers, and authors of learning material. There is yet another facet: namely, the centralizing and standardizing impact of technology on the instructional process.

Technology may help in the management of instructional detail. This includes facilitating testing and measurement of pupil progress. Some devices provide almost immediate feedback on the amount learned. Newer devices provide for almost instantaneous storage and retrieval of data placed in pupil records. This facilitates measurement and reporting of pupil progress. Technology in management can facilitate the transmittal of pupil records from school to school and thus reduce the possibility of loss or distortion. Through certain new media, pupils may be classified in a series of unique groups exhibiting variables important to some types of learning. Technology is being used presently to schedule pupils in simple or complex patterns. It also enables the integration of various media.

Technology may have an impact on educational counseling, insofar as counseling requires more adequate information about the pupil and rapid retrieval of such data. Pupil self-research on interests prior to sessions with counselors represents another illustration of how technology may have an impact in educational counseling.

Limitations of Technology

These are basically the items related to human choices. *Technology can't determine values or goals, nor can it define purposes. Technology cannot overcome bad utilization* of its potential. Its effectiveness rests on the adequacy of human and fiscal resources. In short, it cannot remain effective with inadequate human and fiscal resources. *Technology may result in isolation of the learner.* It cannot accomplish socialization of learning experiences at any other than very pedestrian levels.

Technology may eliminate the need for one type of professional institutional personnel. On the other hand, it may require another type with skills in utilizing a given technology. It may replace the paraprofessional if the role of personnel at this level is simply recording and retrieving basic information that could be handled through a computer-based information system.

Factors Stimulating Development and Implementation of Technology

A number of factors serves to influence the development and

implementation of technology in an educational system. Federally sponsored research and development grants constitute an important positive force. Public readiness to accept technology represents a second. Where technology has proved successful in noneducational endeavors, its lessons may be applicable to education as well. The image projected through use of technology—that is, the greater personal visibility or mobility—is a less often stated but nonetheless important factor in stimulating adoption of new technology. The size of the educational market for the hardware of some technology, such as the computer, is second only to the national defense market. The rising cost of human work forces in education may force reassessment of manpower utilization and may stimulate the search for technological alternatives. The role of education in producing the great society may result in greater resources being allocated to education. The introduction of technology depends on greater resources.

From one point of view, the potential of technology (whether it be totally new concepts or linking it in a better way with existing technology) and its effective influence on the multitude of tasks related to teaching are complicated by a host of other problems and issues that clamor for the attention of today's administrators at every school level. There are enough problems related to race relations, teacher militancy, changing relationships with various levels of government, and inadequate financial resources to tax the energy of the administrator. In addition to these factors, the expectations of citizens as to the role of the school are most challenging. We have not yet begun to find a very sophisticated way of educating society to the need for many changes in education.

The Committee on Instructional Technology has endeavored in its work and in this report to share its experiences and observations in some of the areas that appear to be most pertinent. Some attention is given to the historical influence of technology on education. There is a statement on the influence of technology in the cognitive, affective, and psychomotor domains. The administrator's problems in relation to manufacturers and vendors are explored to some extent.

There is a brief description of the status of technology in terms of new devices and approaches. Considerable time has been spent in exploring the status and promise of the computer as an instructional device. Some consideration has been given to factors outside education that influence the subject. There is some projection of the degree to which and methods by which technology may reshape education and the influence of technology on the partnership of education with government and industry. Finally, there is a statement on forces that the Committee feels will affect future developments in education

and technology.

In closing, it should be stressed once again that technology is a means to an end in instruction. Its value lies in its contributions to improvement of learning and financial savings. If it fails to improve human learning or if costs far exceed alternative approaches to more effective instruction, then it is questionable, indeed. The worship of technology for the sake of technology is self-defeating.

Footnotes

1. Commission on Instructional Technology. *To Improve Learning.* A Report to the President and the Congress of the United States. Washington, D.C.: Government Printing Office, 1970. p. 6.
2. *Ibid.*, p. 7.
3. As reported in Rickover, H. G. "Why We Must Adopt Technology to Human Needs." Washington, D.C.: *The Sunday Star,* May 11, 1969. p. E2.
4. Knezevich, S. J. *Administration of Public Education.* Second edition. New York: Harper & Row, 1969. p. 487.
5. Corey, Stephen M. "The Nature of Instruction." *Programmed Instruction.* Sixty-Sixth Yearbook of the National Society for the Study of Education. Chicago: University of Chicago Press, 1967. p. 6.
6. Commission on Instructional Technology, *op. cit.,* p. 5.
7. Rickover, *op. cit.*
8. Anderson, Charnel. *Technology in American Education 1650-1900.* New Media for Instruction 1, O.E. 34018, Bulletin 1962, No. 19, U.S. Department of Health, Education, and Welfare, Office of Education, Washington, D.C.: Government Printing Office, 1962. 53 pp.
9. *Ibid.*, p. 50.

2. Typology of Instructional Technology

Instructional technology is more than machines adapted to the teaching-learning process. It is a way of thinking and is concerned with new approaches, such as learning systems or organizational arrangements, as well as with the latest cluster of equipment or hardware. Perceptions of instructional technology range all the way from those mysterious little black boxes (sophisticated electronic devices) to uniquely packaged instructional systems, such as those which seek to increase pupils' ability for self-instruction or to improve teacher competencies in a specific area. This AASA Committee, as did its federal Commission counterpart, was forced to "look at the pieces that make up instructional technology: television, films, overhead projectors, computers, and other items of 'hardware' and 'software.' "[1]

Today the textbook is being challenged as the central focus of the learning process by electronic devices, automated equipment, and non–machine-oriented learning systems. It is a difficult and time-consuming chore to retrieve information vital to the teaching-learning process that is stored in printed and bound volumes. And the ever-widening horizon of learning will make rapid retrieval of information more and more essential. The knowledge explosion and the demand for immediate access to data pertinent to problem solving have stimulated the search for a new technology with the capability of extracting information quickly and accurately. Some industries and educational institutions are designing prototypes of programed packages for more effective use by the learner. When educators and learners become "researchers," the speed and accuracy of technological aids determine the effectiveness of the system

for learning which has been devised. This does not rule out the printed word, but rather presents a challenge to the textbook's central position. Giant strides are being made in communications technology as engineers are developing new ways to gather, record, store, and transmit information.

Types of Instructional Technology

Technological developments are so complex and the devices so numerous that a typology is necessary to organize thinking about the various types of instructional technology. The organizational technology reviewed in the previous chapter will not be described in detail in this one.

Mechanical, Optical, and Electronic Devices

The largest class of the so-called wonder devices with applications to instruction are those that are related to the technological developments in photography, communication of audio signals, transmission of visual images, and electronic or computer-based processing and storage of data. Various possible combinations of these basic technologies can be used to produce a very large number of instructional devices.

Photography

The integrated system of optical, mechanical, and chemical components that captures an image on sensitive film and/or projects the developed film image on a screen is called photography. Light-sensitive chemical compounds are exposed by means of a device called a camera. The exposed chemical compound is "developed" and then "fixed" to preserve the picture. The end product may be used in several forms, such as the still photograph, slide (of various sizes), filmstrip, silent motion picture (of various sizes), sound-on-film motion picture film (of various sizes), microfilm, and microfiche. This technology gave birth to what has been called audiovisual (AV) instruction. Developments during the World War II years and in the subsequent post-war years stimulated the spread of AV materials and equipment. It is perhaps the oldest of the new techniques.

The image produced by photography may have a sound track attached to it to explain or dramatize it. Projectors of the end products and the screens are components of the total photographic system.

Improvements in projection devices made since the 1930's are recognized for their gains in efficiency. Film sizes have been reduced from the "large" 35mm to 16mm without much loss in quality of the image produced. The first breakthrough in this domain came with the 16mm film size. Further economy in operation by industry, educational systems, individual schools, and even students came with the 8mm size. It was improved

and then glamorized as the "super 8mm." The 8mm sound-on-film shows promise of being a most convenient package for classroom use of teacher and pupil.

Black and white films are being replaced, and budgets are being revamped in order to provide for color in film production. Rear screen and front screen projectors are now available. A central projection room may provide showings of several different films at one time, with viewing rooms built around such a central projection room in a cluster-type arrangement. The experience with large rear-screen projection suggests that it is not the most feasible alternative. Projectors and other allied equipment are moving from the silent and sound-on-film category to the capability of handling film cassettes. The task of threading a projector is eliminated by the insertion in a projection device of film packaged in a plastic case. This is done without thought as to errors in winding and rewinding. The so-called single concept film is most readily adaptable to the film cassette format.

Filmstrips and slides have not been lost along the way. Rather, new potentials are being explored as evidenced by efforts to coordinate filmstrips with a sound reproducing device. In addition, two or three filmstrips may be employed in sequence to produce unusual effects and impacts. Cartooning and symbolic picturizations are being used in filmstrips and slides for the new generation of learners who can remember the ad man's slogan in commercials without reading anything.

Microfilm and microfiche readers promise unlimited information to teachers and the teaching machines of the future. These are extensions of the technology built on image reproduction and projection. Microfilm and microfiche can be called new technologies only in the sense of being further and recent refinements of a basic technology in photography and image reproduction.

Although technology related to photography has been around for a long time and has become known as a relatively mature technology, its exciting possibilities in instruction have not been exhausted. The recent use of regular cameras by ghetto students to take pictures of themselves and their environment has yielded some most interesting educational benefits. The creativity of the user appears to be the most serious constraint in the instructional applications of this well-developed technology.

Audio Technology

The recording and reproduction of sound, first by mechanical means and later by electronic devices, represents another variety of technology which has influenced instruction to a considerable extent. However, what is said to stimulate learning

must not be lost in the glamour of transmitting signals over wire or by means of radio or microwaves. The telephone-based communication system may be adapted to serve the learner well in a new setting called the "dial-access system of communication." This can be an in-school system, usually placed in special carrels in the library. The telephone becomes the connecting link between "libraries" of information recorded on tape and the learner who wants to use the information. In some cases it permits instruction of students who are home-bound or hospital-bound by an illness or handicap. Telephone wires can be used to connect the learner with special teachers or with special libraries or other centers of information.

Portable tape recorders in study carrels and laboratory settings are used commonly in many different types of instructional environments. Phonographs are standard teaching aids in many schools. Education and industry are constantly exploring the effectiveness of the tape recorder for individualization of instruction, as well as large-group instruction. Further research is being conducted in the interests of reliable sound reproduction to reflect the more subtle nuances of music and drama.

The language laboratory is a post-World War II product which was first formalized as a concept and put into practice in 1947. It started with discs played on conventional phonographs. Magnetic tape recordings came later. The magnetic tape technology improved rapidly so that by 1958 these devices replaced phonographs. Two factors combined to produce a tremendous upsurge in utilization of language labs in the late 1950's and all of the 1960's. One was a policy change in 1956 by the Modern Language Association that fluency in communication was to be the ultimate objective of language study. Also, the National Defense Education Act of 1958 made available millions of dollars for the purchase of language labs. The high watermark was reached in 1962-63 when 10,000 labs were installed, with a peak annual equipment outlay of $11.9 million.[2] In other words, a policy stand by a reputable educational group and federal funds provided the conditions for rapid adaptation and acceptance of the technology based on magnetic tape recording.

The difference between a collection of tape recorders and a well-planned language laboratory is that the latter provides for a teacher's console, a soundproof recording room, a library for tapes, a screen for projection of films that may be used, and facilities for production by participating students. One of the problems encountered with language labs at this time is that the utilization level appears to be falling below what was expected during the days such labs were being installed in large numbers. The federal Commission on Instructional

Technology reported "a serious lack of software" for language labs. As a result, the intensive experience of nearly a dozen years demonstrated that "it is clear that language laboratories have realized only a fraction of their educational potential." [3]

Business and commercial education laboratories utilize similar recording technology. Exercises to improve typing and dictation skills are played to students via magnetic tape recordings. The built-in flexibility allows for large-group and individualized instruction.

Music centers, by their planned arrangement of facilities, may extend individual instruction and provide appreciation of good music to more students than ever before. The introduction of the piano laboratory, where the use of a console instructional board and individual electronically controlled pianos and headphones for students, has extended the instructor's service to many students, rather than just one. An additional advantage of the piano laboratory is that it can be placed in any classroom setting, since the sound need extend only to teacher and student. The music center can be equipped with highly sensitive sound systems so that recordings can be broadcast to large groups as well as to individual carrels. Soundproof areas are often provided where records and tapes can be made by both students and instructors.

Individual carrels and study centers equipped with access to magnetic tape recording equipment are planned now for many new school buildings. They are located in libraries, resource centers, dormitories, and media centers where research is conducted. There appears to be a trend toward construction of more laboratories and resource centers with the result that schools are becoming media-centered.

Radio was among the first of the electronic communication marvels, first by AM and later by FM transmission. It allowed for the long-distance transmission of sound without wires. In the 1920's, radio was considered revolutionary. A number of special school instructional programs were beamed throughout a state to serve small and isolated communities. Today the instructional uses of radio are so common that they are no longer categorized as a "modern marvel" of communication or of instructional technology.

The "talking typewriter" uses magnetic tape recordings coupled with typing keys that are in effect switching devices. It has received much attention because of its use in teaching very young children and adults to type and read. Techniques and machines have been refined to the point that the students are placed in an automated, responsive environment and are able to translate written symbols into spoken ones and to translate spoken symbols into written words. The relatively high cost of this device has, as yet, limited the number of school

systems willing to experiment with it.

Video Transmissions

The transmission of images as well as sound via electronic means makes up the technology known as television. Educational, or instructional, television (ETV) is of recent vintage. Educational telecasting in 1968 was a $200 million a year business and reached 120 million people in all but three states. Groups of states, school districts, county systems, and individual schools now sponsor educational television. Closed-circuit (CCTV) and open-circuit television are in common use. Closed-circuit television installations in 1967 were found in 717 public schools and universities, almost double that of four years before. About 47 percent of these were in public elementary and secondary schools. Instructional Television Fixed Service (ITFS) (2,500 megahertz television) is a relatively new development with great potential but with as yet limited use. About 100 ITFS installations were reported in 1967. Video tapes represent a new direction for educational television, with savings in production costs and greater flexibility in time scheduling a distinct possibility. Large video tape program libraries are to be found in several regions of the nation. Electronic Video Recording (EVR) along with community antenna drops to specific locales and the possibility of distribution of signals through satellites also demonstrate promise. Effectively planned television programs generally provide for all new programs to be in color.

As a considerable degree of its glamour has been lost, ETV, although one of the newer technologies, is suffering the fate of radio. The refinement and lower cost of videotapes to store visual and audio material without significant loss in fidelity give greater flexibility to this media in the instructional process. Materials stored on videotape can be utilized without disrupting school class schedules. Further packaging may make it feasible to utilize it in a library setting for some without disturbing others close by. The instructional potential of ETV has not been reached as of this writing, even though its use in public education is large enough to call it a commonly used technology. Open-circuit instructional TV finds elementary school pupils as the major audience. The federal Commission reported that instructional TV in 1970 filled "less than 3 percent of total classroom hours in the elementary and secondary schools of the country's 16 largest cities." [5] TV and radio are being used to "enrich" rather than to modify instructional practices. Again, "underused studios are constant reminders of television's status in American education at the present time." [6]

Audio tapes and television screens are being installed in carrels so that a student may see and hear information rather

than look for it in books. The federal Commission on Instructional Technology estimated that "there are an estimated 120 dial-access information-retrieval systems" in educational systems and universities.[7] Some colleges are working with regional telephone companies to perfect plans for installing a tape center on the campus with telephone lines to dormitories. This will enable the student to dial a specific number and listen to the reference work assigned by his instructor for the next day's lesson. Dial-access systems are being devised for areas covering many states and, therefore, many classrooms. Many of the existing dial-access systems grew out of what started out as a language laboratory. In most places the effectiveness of present level systems of instruction has been slight and the installation and operation costs very high, sometimes over a hundred thousand dollars. It is well to point out that an information retrieval system does not dictate the quality of learning. Nonsense recorded on magnetic tape is still nonsense whether it comes out of a learning lab or a dial-access system. Perhaps this explains why expensive equipment has been neglected to accumulate dust. This is not unusual where hardware or equipment development far exceeds the capacity of the profession to develop meaningful software.

Electronic Data Storage and Processing

The storage of information which can be retrieved subsequently to meet the needs of an instructional situation or the processing of other data used or generated during instruction by means of computer-based electronic devices is one of the newer and more exciting technologies. It was pointed out in previous paragraphs that the same information could be stored on magnetic audio tape. Its retrieval from audio tape is relatively slow and must be sequential.

The heart of an electronic data storage and processing system is the electronic digital computer. Insertion, manipulation, storage, and retrieval of information can be accomplished at fantastic speeds with this machine, for electronic impulses that form the basis of its actions can flow through a conductor at a speed of 186,000 miles per second. It also provides random access retrieval capability. No mechanical processing machine can begin to approach the speeds or other capabilities of the computer.

The computer was developed to solve noninstructional problems and has multiplied man's intellectual powers in many fields. To adapt computer technology to education required new ways of presenting learning sequences to pupils, new roles for teachers, and new patterns for scheduling and organization for instruction. Like most machines the computer depends on a software component to enable it to run meaningfully. Com-

puter characteristics satisfactory to scientific problem solving had to be modified, for example, to place more emphasis on storage capacity and ease of programing changes and to meet instructional demands with relatively less concern on speed and computational capability.

Most discussions of the use of instructional technology in schools, by implication, focus on the computer in the instructional process. For this reason, Chapter 3 is devoted to the instructional uses of the computer.

Computerized instruction is the most sophisticated of the new technological aids to education. The extensive use of computers in industry and the Department of Defense for the purpose of logistical planning has made education aware of the computer's potential for use in the classroom. In addition, a real need exists for computers in the time-consuming task of administering programs in education. The use of computers in the educational field has resulted, in many cases, in attendant fears as to the role of the teacher and concern over the reduction of the humanizing forces needed in the learning process.

New Systems or Approaches

In the previous classification, the unifying factor was one of devices, hardware, or equipment. It is easier to comprehend educational technology as machines adapted to the purposes of instruction than its more sophisticated conceptualizations. Flashy gadgets with marvelous capability are readily visible to visitors to "experimental schools," whereas the systems that lie behind and actually make the hardware work are more difficult to understand. This typology of instructional technology recognizes a second category which focuses on systems or approaches that make a machine function as it should, that organize and sequence experiences, or that generally unify the various activities that make up the instructional process. These systems or approaches can be classified as the intellectual technology or "software," as opposed to "hardware."

The physical expressions of technology facilitate transmission, dissemination, or assimilation of concepts or skills to be learned. Closed-circuit television, for example, is a way of projecting a teaching-learning situation within a given situation. What appears on the television monitor can be no better than what is captured by the TV camera. Instructional television (ITV) may disseminate poor teaching as well as quality performances. Stated another way, the quality of the instructional materials that go into a computer system will determine the effectiveness of computer-assisted instruction. Persellin put it as follows:

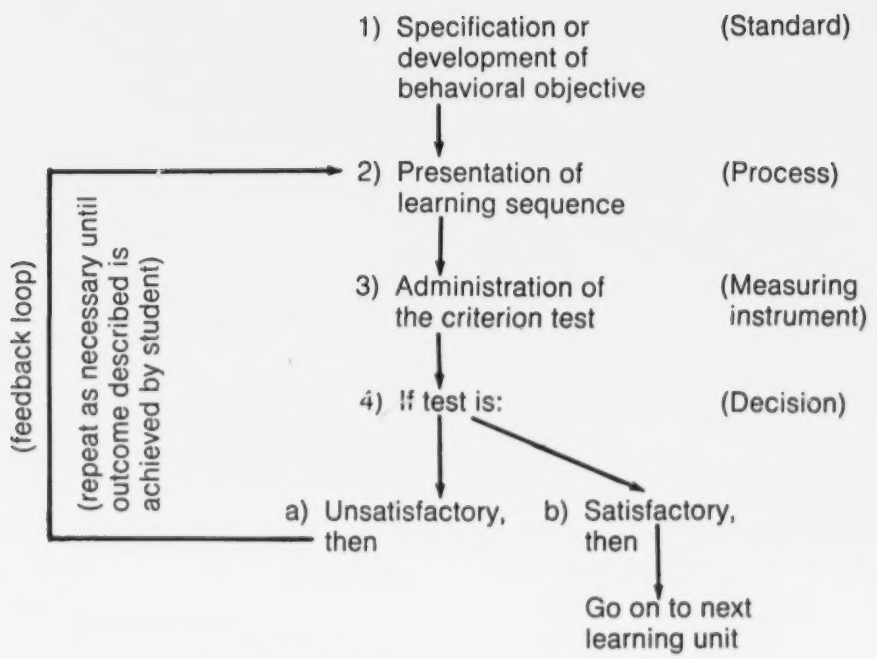
New instructional devices or techniques cannot be created and introduced in the school environment in isolation from the state of the art in curriculum development and the mainstream of administrative and instructional policy and practice.[8]

The so-called teaching machines boomed in the early 1960's and then all but disappeared. This testifies to the fact that there is more to educational technology than aggressive marketing by vendors or generating a demand through publicity. The technologist must produce the innovation that education needs to attack persistent problems, for only meaningful innovation will stand the test of time.

There are at least two important subdivisions of what can be called the intellectual technology: (1) programed instruction and (2) the systems approach. Each of these will be reviewed briefly.

Programed Instruction

The intellectual technology that gave rise to programed instruction—that is, the systematic arrangement of content to be learned—can be traced in its very rudimentary form to the Socratic method and the catechetical instruction techniques used by the early Christian church, as well as to the behavioristic psychology of learning which began to gain prominence around the turn of the century. Programed instruction is based on the sequencing of materials or the organizing of experiences in a preset order for presentation to a learner. The learner's response is evaluated immediately on the basis of a pre-established set of standards to reveal to what degree the knowledge, insights, and skills have been mastered.[9] It is characterized by (a) organization of material to be learned into separate, discrete, and relatively small or manageable units of learning; (b) the learner's interaction with each small unit of learning in a step-by-step fashion; (c) immediate feedback to communicate the level of mastery of the learning material presented to the learner; and (d) self-pacing with a step-by-step process of mastery. To produce this systematic approach to learning demands clear specification of behavioral objectives to be achieved, presentation of a sequence of learning exercises with the above-stated characteristics, development and administration of a criterion test to measure the performance level, and a decision following interpretation of the performance as measured by the criterion test. The so-called feedback loop is evident when the test score is judged to be unsatisfactory. When this is the case, the same sequence of learning activities is repeated. (A diagram of the feedback loop appears on the following page.)



The well-known workbook represented in printed form early and crude efforts to program learning for pupils. The programed text is a more recent and more sophisticated printed form. Computer-assisted instruction is programed learning employing the computer's ability to store information, to present questions to the learner, to receive the learner's response via typewriter or cathode ray tube, and to evaluate the pupil's response. The programed instruction (PI) format can be hooked up to a variety of hardware such as "teaching" machines of varying sophistication, computer-based instructional devices, instructional television, or even paper (the programed text). PI is what drives the machines. Without PI the machines would have nothing to say and no impact on learning or instruction. The importance of PI to the technological hardware is difficult to overestimate.

What is called programed instruction or learning is a way of thinking about the learning process. It is an approach based on breaking down a complex learning task into meaningful and related bits or units, and implies a psychology of learning. Programed learning is as valid or effective in promoting learning as is the psychology on which it is based. It can be coupled with other means, such as a piece of computer hardware or a printed volume. Immediate reinforcement is one of its most vital aspects.

Lange painted a realistic picture of the development of programed instruction and suggested three major phases:

1. Initial exuberance, accompanied by an enthusiasm, and overselling of rudimentary and imperfect program designs.
2. Disillusionment with programed instruction as the poorly developed products failed to match the claims of early proponents. (Many schools dropped it when expected learning gains and cost savings failed to materialize.)
3. A more balanced approach whereby the remaining core of researchers and developers work to perfect the instructional technology rather than exaggerate its virtues.[10]

The federal Commission noted that "one important reason for the decline in the use of programed instruction was that the teaching machine came on the market long in advance of the appropriate software."[11] As a result, the sale of programed instruction materials to education today represents a small fraction of the total amount spent for textbooks. This is true to a lesser extent in the armed services and in industry.

Systems in General

The systems approach is yet another social, rather than physical, invention. It is a generalized process for applying scientific knowledge to practical purposes. It demands careful specification of missions in terms of behavioral outcomes, interdisciplinary teams working on instructional problems, development of alternative strategies for reaching a goal, emphasis on the whole or interrelatedness of elements, the generation of models, and sophisticated quantitative reasoning tools. "Instructional systems" began to be spoken of with regularity around 1960. The total system may include specialized instructional strategies, programed instructional material, conventional textbooks, several of the existing media (such as films and slides, workbooks, supervisory personnel, computer programs), and inservice experiences. It must include also the proper facilities, the means for keeping the system working, and the basic methods by which staff and students will be involved. Terms such as *instructional packages, special inputs, monitoring of pupil progress,* and *measured outputs* are a part of the jargon that accompanies instructional systems. The linkages among the component parts of the system are important to its operation. The human components in the instructional system can vary considerably in capabilities.

The contribution of systems is that they have stimulated new ways of thinking about education. Many attempts have been made and are being made to systematize the educational task. The terminology begins with systems and subsystems and extends to instructional systems, systems theory, systems analysis, and total systems. New specializations—instructional systems designer and instructional systems manager—may be emerging. Examples of instructional systems can be traced

from the graded textbook and workbook to "kits for learning," film presentations in specific academic areas, and highly structured teaching guides which are all-inclusive in providing resource materials and teaching aids. The Biological Science Curriculum Study is a good example of the completely structured program, with teacher-training as a major component.

The Individually Prescribed Instruction (IPI) program and other similar programs are directed toward developmental and unrestricted pacing of students, with use of sophisticated technology in those parts of the procedure where more efficiency can be achieved by such aids.

Observation and actual participation in any programs bring an awareness of the need for a "total systems" approach. Administration, organization, staff training, student involvement, physical plant provisions, and all other educational considerations must interact and interrelate in an effective way before the real value to the learner can be determined. For this reason, the adoption of any single programed series or the piecemeal adoption of technological aids probably will have only a negligible effect on the learning process.

Other Approaches

The manner in which pupils are organized (graded or nongraded), in which they are grouped in an attendance center (junior high or middle school), in which teachers are deployed (individual teacher–class situations or team teaching–class situations), and in which pupils are paced (traditional total class instruction or individualized "study contracts") are illustrations of various organizational approaches designed to obtain promotion of learning. These were reviewed in the previous chapter.

Technology Based on Biochemical Approaches

The rat-brain research of Krech and others may generate another technology that could influence ability to learn as well as rates of learning. More specifically, it is derived from efforts to discover the physical basis for memory by examining the chemical, neurological, and anatomical factors involved in what is called memory.[12] The research developments in brain biochemistry suggested that the production of new proteins, the release of differentiated molecules of ribonucleic acids (RNA's), or the induction of higher enzymatic activity levels in the brain could be involved in memory. This, in turn, led to the idea that "for every separate memory in the mind there is a differentiated chemical in the brain—chemical memory pellets, as it were." [13] During experimentation the maze-learning ability of rats was improved by injecting them with the chemical known as metrazol. It was reported that "under metrazol treatment, the hereditarily stupid mice were able to turn in better

performances than their hereditarily superior but untreated colleagues." [14]

Krech emphasizes that "get-smart pills," "chemical erasures of wrong mental habits," or "specific knowledge pills" may change but will not reduce the importance of educational experiences or the contributions of the educator. In other words, it suggests the development of an "enzyme-assisted" instructional technology. Krech and others point to research that indicates that the chemical and morphological qualities of the brain can be modified by the quality of the educational environment, nutritional factors remaining constant. Rats placed in an intellectually enriched environment, as compared with brother rats from deprived environments, had brains with—

. . . a heavier and thicker cortex; a better blood supply, the diameter of the blood vessels being larger; larger brain cells; more glia cells (glia cells were also found in the brain and play a very important function in the nutrition of the brain cells, among other things); and increased activity of two brain enzymes.[15]

Therefore, the educator can influence for good or ill the work of the brain's biochemistry by manipulating the educational and psychological environment.

Influencing learning through the administration of biochemical or pharmacological substances to pupils is still a bold but imprecisely defined idea. As a technology it is in a rudimentary state of development. What chemicals will stimulate learning among pupils without any serious and deleterious side effects or what chemical compounds can enhance the retention and retrieval of data in the human mind is a matter of research that must go beyond what we now know about rats. It may come to pass that chemicals will be discovered that overcome student apathy, lethargy, or loss of vitality and that may make students more responsive to one type of instructional media than to another. These substances may be spread on foods eaten in the school cafeteria via a "salt shaker" or they may be circulated in a gaseous state through the ventilating system.

At the moment, the questions of what chemicals can alter human behavior, personality, or learning capability remain unanswered; these questions take precedence over the procedural aspects. What is now a laboratory curiosity may generate an intense debate on the morality, as well as educational advantage, of using drugs to stimulate learning. CAI may come to mean "chemically assisted" as well as "computer-assisted" instruction. In other words, what is now achieved through drill-and-practice may be accomplished more quickly and surely with the help of enzymes to influence the brain.

Instructional Technology Under Development

At present, education appears to be beginning the process of what can be called "technological capital formation." It is hoped that the foregoing typology may help in distinguishing the various components that go into developing a firm base of hardware and software for instructional technology. It will take time to accumulate this specialized type of capital in education to the point where it predominates in all phases of educational activities. Of course, new ideas will continue to emerge, and their implementation in the schools will always lag behind their discovery.

In the early years of technological capital formation, confusion should be expected because people will have difficulty in distinguishing between ultimate promise and immediate possibility. Our times seem to be obsessed with the media rather than the message, with doing things in an innovative way rather than with achieving certain outcomes.

Instructional technology, by definition, is the purposeful manipulation of the learning environment of pupils by means of what can be called hardware and software. Some view instructional technology as a new name for what previously was called audiovisual instruction, with the addition of new gadgets such as ITV (instructional television) and CAI (computer-assisted instruction). Others see it as a glorified language laboratory, based on magnetic tape recording technology.

Experimentation in computerized instruction, with and without visual displays or with and without an audio component, is under way in industrial and educational research centers. Industry has spent large sums of money in research and production of electronically controlled machines for the purpose of determining whether or not computerized instruction can extend to education the aids it needs at a price that it can pay.

Some industries have coupled their contribution with that of the Office of Education and philanthropic foundations to conduct computer-system instruction programs in several cities simultaneously. Industry is already cognizant of the need for programed materials (software) and well-defined objectives for the most effective use of their product. Such industrial organizations have included money in their funding programs for the hiring of writers and behaviorial science specialists.

Pilot programs in computer-assisted instruction are so organized that instruction is on an individual basis, with each child progressing at his own pace through a subset of materials designed to best suit his particular aptitudes and abilities. A basic premise, which educators must assume in their use of technological aids, is apparent: namely, that education must develop a theory of instruction which will de-

termine the most effective system of sequencing the student through the instructional field.

Another interesting and innovative approach to curriculum organization is the use of technological aids and computers to facilitate the Individually Prescribed Instruction (IPI) approach. Impressive results have been achieved in programs in which students used computers to gain background material for vocational guidance considerations.

Technology and Libraries

Technology is reshaping libraries—an integral part of every school system and an important part of many learning experiences. Computer systems, microform techniques, and special publication techniques are available for adaptation to library purposes. One source estimated that in 1967 only 3 percent of libraries in the United States had begun to use data-processing techniques.[16] Thus far the use of data-processing equipment in libraries has been confined, by and large, to the technical processes, such as circulation control, rather than the reference services. Computer-based bibliographic search and retrieval systems, such as Systems Development Corporation's (SDC) ORBIT, are available even though they are not in extensive use as yet.

A fully automated indexing, classifying, abstracting, and extracting "service" appears to be a long way off, according to Lanham.[17] Technology can aid libraries in such areas as circulation of materials, reference sources, and distribution of materials. Library materials may soon be kept in a variety of ways: microforms, videotapes, holograms, computer storage, and other forms which advanced technology will produce. It will take some time for research and development to adapt new technologies to library purposes, for libraries to get the funds to invest in computers and related hardware, and for library personnel to be trained in the uses of the new technology.

Centralization Impact

Systems analyses of the capabilities of the computer in the performance of administrative and scheduling tasks showed how such burdens could be lightened for school systems, and such use seems quite likely in the future.

The centralization of technological aids into one major arm of the school system represents a new direction for many new schools and colleges today. Such centers serve as the hub for all television and film production for an entire school system. This kind of arrangement requires a change in the staffing pattern for the educational institution and efforts on the part of staff and students to make technological aids better serve

learning needs. Other projects are structured to use the computer exclusively as a test-correcting and processing device. Individualized instruction is still the ultimate goal of the program, with the computer being used to provide readily accessible information to the teacher.

Relations with Industry

Industry and education need more field testing of technological aids. Some universities are conducting field tests, but there is no effective way of distributing the results to the general public or to administrators. Industry has a responsibility to the consumer to show the results of field testing of their products. Many technological aids are sold to elementary and high school administrators, with judgments as to their effectiveness confined primarily to the experience of the industry producing the product and, perhaps, to some extent from applications in the armed forces or other governmental agencies. This may change in the future. The relatively new organization known as the Educational Products Information Exchange (EPIE) has demonstrated a willingness to gather more relevant data on a new product's capability. EPIE publishes reports on the characteristics, costs, and user evaluations of a large variety of instructional artifacts.

The learner in educational institutions is less mature, is found in different settings for learning, and has a different motivational level than the learner in industry or the armed forces. Therefore, he has different requirements for technical aids. There is a definite responsibility on the part of both industry and education to bring more realistic testing of new instructional artifacts out of the dialogue stage onto the field of action. Schools represent the second largest market in the nation for technology, and industry must perfect and tailor technological products to the needs of this market. Perhaps EPIE will contribute much to this end.

The terms *hardware* and *software* are in common usage in the technological age. Software represents the basic content of instructional material and the manner in which it is presented. Hardware literally means the technological aid through which it goes to reach the learner. The old "GI-GO" expression which came out of the early days of the computer still applies. This simply means "Garbage In–Garbage Out." Industry and education are both aware that the software to be used in the instructional task cannot be the largely meaningless printed word of the conventional textbook of the past. If such software is used, educators may well deserve to be called "purchasers of electronic page turners." Corporations and educational research and development centers are being staffed to create and market educational materials and systems for learning.

Training and development of educators who can create meaningful programed instruction are being provided on an ever-increasing scale.

Status of Utilization of Technology in Education

The AASA Committee on Technology and Instruction concurs with the federal Commission on Instructional Technology which reported recently that "the impact of technology on instruction has been small compared with the magnitude of the educational system in the United States as a whole." [18] Sizable investments in instructional hardware have been made by the schools. The estimated number of items of audiovisual materials and equipment owned by U.S. public schools looks impressive, as evidenced by the inventory shown in Table I.

Table I

Estimated Number of Items of Audiovisual Materials and Equipment Owned by U.S. Public Schools, July 1969 [19]

SELECTED EQUIPMENT		SELECTED MATERIALS	
Screens	919,000	Filmstrips	21,700,000
Record players	698,000	Still and flat pictures	12,400,000
Earphones	576,000	Disc recordings	7,200,000
Overhead projectors	453,500	Overhead transparencies	5,230,000
Slide and filmstrip projectors	426,000	Maps and globes	4,200,000
Tape recorders	320,000	2-by-2 inch slides	2,400,000
16mm projectors	251,000	Tape recordings	2,020,000
Learning carrels	171,000	16mm films	1,315,000
Slide or filmstrip viewers	163,000	Reading programs	336,000
Reading devices	98,600	8mm films	104,000
Opaque projectors	91,600		
Transparency makers	71,200		
8mm projectors	58,600		
35mm slide cameras	27,200		
Rear screen projectors	22,200		
16mm cameras	14,100		
Drymount presses	11,750		
8mm cameras	7,200		
Microprojectors	6,180		

NOTE.—The total number of public schools operating in 1969 was estimated at 92,500.

Source: Loran C. Twyford, New York State Education Department, 1969.

Accumulations of instructional hardware are a rough indicator, at best, of the impact of technology on education. How well the equipment and materials are utilized is more important. The general opinion of the AASA Committee is consistent with that of the federal Commission, namely, that even expensive and sophisticated hardware is underutilized and in some cases simply collects dust. Research on the relationship between the use of one technology, television, and learning suggests that "effective use of television grows out of attention to the basic requirements of good teaching, rather than to any fanciness that might be peculiar to television." [20]

The relatively limited impact of new instructional equipment at this time emphasizes the importance of the software and personnel dimensions of technology. Machine development has far outstripped the development of programs that run the machines and make pupil-machine interaction meaningful in the learning process. Furthermore, machines and their programs are means. They involve people. There is a serious interface problem between machines and the people who use them to learn as well as those who prescribe their use to learners. Instructional technology is a man-machine system. Investments in the preparation or retraining of instructional personnel to make best use of the new technology must be at best equal to the amount invested in equipment. The magnitude of these expenditures for staff development can be estimated from the following indication of 1968 sales of the audiovisual industry:

The nation's educational institutions continued to comprise the largest segment of the audiovisual industry. This year (1968) sales of software and hardware, plus the internal administrative costs, came to an impressive total of $570 million, up 6 percent.[21]

Footnotes

1. Commission on Instructional Technology. *To Improve Learning.* A Report to the President and the Congress of the United States. Washington, D.C.: Government Printing Office, 1970. p. 19
2. Persellin, L. E. "Conditions for Innovation in Educational Technology." *Educational Technology:* 5-8; December 30 1968.
3. Commission on Instructional Technology, *op. cit.,* pp. 75-76.
4. National School Public Relations Association. "Priorities for School TV Probes." *Education USA* 81; December 2, 1968.
5. Commission on Instructional Technology, *op. cit.,* p. 68.
6. *Ibid.,* p. 69.
7. *Ibid.,* p. 77.
8. Persellin, L. E., *op. cit.,* p. 8.

9. See Lindwall, C. M., and Bolvin, J. O. "Programed Instruction in the Schools: An Application of Programing Principles in Individually Prescribed Instruction." *Programed Instruction.* (Edited by B. C. Lange.) Chicago: University of Chicago Press, 1967.

10. Lange, B. C. "Future Developments." *Programed Instruction.* (Edited by B. C. Lange.) Chicago: University of Chicago Press, 1967. pp. 286-87.

11. Commission on Instructional Technology, *op. cit.,* pp. 71-72.

12. Krech, David. "Psychoneurobiochemeducation." *Your AASA in Nineteen Sixty-Eight-Sixty-Nine.* A Record of the 101st Annual Convention. Washington, D.C.: American Association of School Administrators, 1969. pp. 91-105.

13. *Ibid.,* p. 94.

14. *Ibid.,* p. 95.

15. *Ibid.,* p. 98.

16. Lanham, Richard. "Marian the Technologist." *SDC Magazine* 11: 2-9; November 1968.

17. *Ibid.*

18. Commission on Instructional Technology, *op. cit.,* p. 65.

19. *Ibid.,* p. 66.

20. Chu, Godwin C., and Schramm, Wilbur. "Learning from Television: What Research Says." An Occasional Paper from ERIC at Stanford. Stanford, Calif.: ERIC Clearinghouse on Educational Media and Technology, August 1968. 213 pp. (Mimeo.)

21. Hope, Thomas W. "Market Review: Nontheatrical Film and Audio-Visual 1968." *Journal of the SMPTE,* November 1969. pp. 973-88.

3. The Computer and Instruction: The Promise of an Advanced Technology

A considerable amount of awe and glamour surrounds the computer today. It is on everyone's list of present-day marvels and wonders. To some it is a frightening gadget with superhuman powers. The less one's knowledge of this predominantly electronic device, the more likely one is to overestimate its powers and ignore its limitations. The first of the three AASA groups probing various aspects of technology issued a comprehensive analysis of computers and electronic data processing in general. The reader is referred to the 1968 AASA publication entitled *EDP and the School Administrator.*[1] Only a brief summary of how the computer operates will be presented here, with particular emphasis on those factors that may have an impact on the teaching-learning process.

Computer Essentials

The digital electronic computer is the most common variety, far outstripping the number of analog computers. The storage capacity, sometimes called memory, is the important difference. The digital computer has a memory; the analog machine does not. From this point, the term *computer* will refer to the digital variety unless there are indications to the contrary. Not all digital computers are exactly alike. They differ in amount of storage capacity, flexibility of inserting data, speed in executing operations, and versatility.

The computer is an electronic device. Numbers and letters that are meaningful to humans must be translated into a series of electrical impulses before they can be stored, retrieved, or manipulated within a computer. The slowest of the many computer processes are those related to feeding printed data into the machine and retrieving printed information from the machine. Once within the hardware, data can be manipulated at speeds that stagger the imagination.

The computer processes facts and figures according to a

prearranged plan. This implies that the user knows what outcomes are desired, how the data are to be organized into a new and more useful format. Three operations are basic to understanding how a computer works: namely, (1) input, (2) processing, and (3) output. Every computer has some means for inserting data into the electronic machine. This requires organizing input data in a machine-usable form. Keep in mind that data comprehended by humans must be translated into electrical impulses to be comprehended by the machine.

Input

There are two types of input. One is the data to be acted upon in some way (numbers that will be added, subtracted, multiplied, etc.). The second type of input is a series of commands or directions for the computer. These commands, called the computer program, cause the machine to treat the data in a prearranged fashion.

There are several ways to insert data in machine-usable form ready to be manipulated by or to serve as the program for the computer. The best known method is via a series of punched holes arranged in a coded pattern on the data card. The card itself is a simple piece of thin cardboard with standardized dimensions. The holes allow an electric circuit to be completed, which in turn generates the pulses of electricity that stand for letter or numbers. It is these pulses that the computer stores or manipulates in a given way. A punched data card showing the significance of the rectangular shaped holes in terms of letters of the alphabet, numbers, or special characters is shown in Figure I.

Magnetic tape is another form of input. Feeding large batches of cards into a computer is a slow process because it is basically a mechanical operation. A much faster input system utilizes a reel of magnetic tape on which data are recorded. The magnetic tape stores minute magnetic charges in a coded pattern similar to that found in punched cards to represent written information. (See Figure II.) Of course, punched cards must be used to get the data onto the magnetic tape. But the same tape may be used many times after that as an input device.

There are other input forms. Paper tape input devices are relatively uncommon but nonetheless are used for some applications and machines. Great strides are being made in developing optical scanners that "read" printed data into the computer. This emerging input device may render the keypunch operator obsolete, for it can automatically prepare a punched data card as well as feed data into a computer.

Processing and Programing

Once inserted, data are processed according to plan. As

Figure I

Coding of Information on Punched (Hollerith) Cards

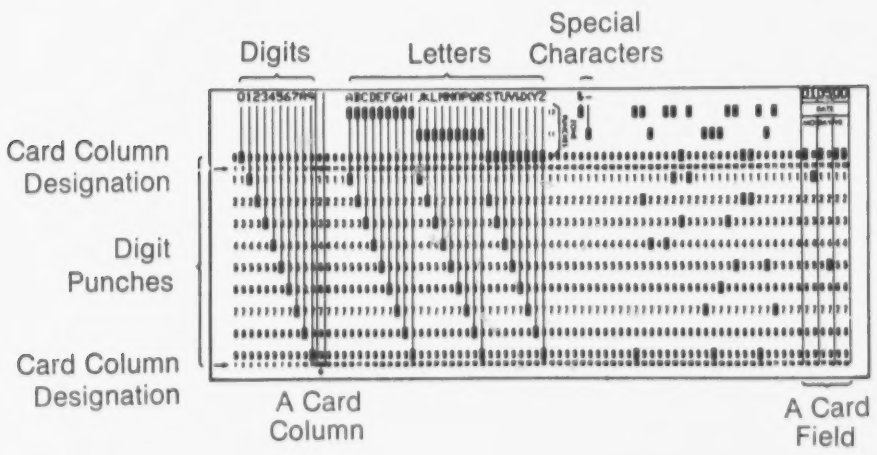
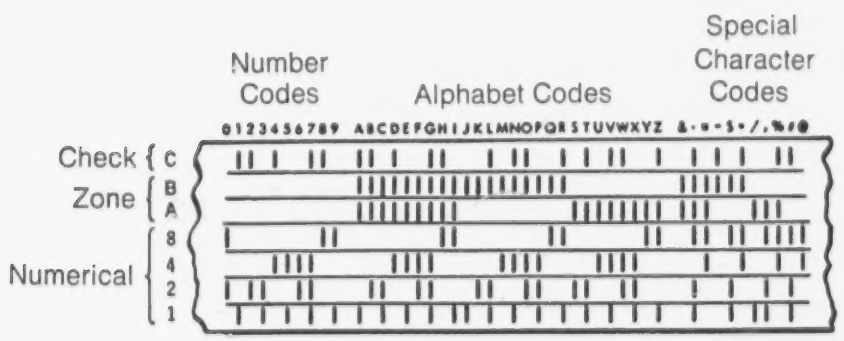


Figure II

Coding of Information on Magnetic Tape



wonderful as the computer may be, it cannot perform all functions instantaneously, nor process all data at precisely the same time. This is why an internal storage device is important. The term *memory* conjures up an image of the computer as a "brain" of sorts. Data not being acted upon at a given moment are placed in storage until such time as they are needed in processing. Storage may be within the main computer frame or it may be outside the machine. Thus, external storage devices, such as a reel of magnetic tape or a special disk which can be connected subsequently to the main frame, may be used. The various generations of computers are distinguished by the type and capacity of internal storage. Thus, second generation equipment stores data (in the form of magnetic charges) in a series of small iron cores, each of which can be magnetized or demagnetized quickly. A charge of a magnetic iron core is equivalent to the number 1 and no charge to 0. Any number in our decimal system can be converted into a binary number, which can be expressed with these two digits. Information is stored as binary numbers. Third generation hardware stores information internally on specially designed thin magnetic film. The film is less expensive than iron cores and makes practical the design of large internal storage capacities for computers.

Another device is required to ensure that the complicated and high speed activities are executed in proper sequence and without confusion. This is the control mechanism. Control of various operations could be performed manually by an operator pushing buttons. This is done rarely for it is much too slow and too susceptible to error and breakdown. Computer processes are so complex that the timing could be upset easily by manual operation. Control is accomplished automatically by means of the program of instructions before the data to be manipulated are inserted into the computer. In the language of data processing, the computer is "programed" to execute certain operations without external interference.

Processing, according to a preconceived plan, is the main function of the computer. Thus, the computer can rearrange information fed into it. It can add, subtract, multiply, divide, and perform other mathematical operations, thus solving complex problems in a very short period of time—problems that would take days or months to do without the computer. The computer can determine whether one number is larger than another. It can search its storage registers and select one bit of data ("stored" as a binary number) that has certain characteristics and reject all others.

Output

What goes in must come out. The output calls for the reverse of the input process, for now the electrical impulses that the

computer understands must be translated into data forms that are meaningful to people. A printer is activated in a special way to yield a printed output. The output can be punched cards or magnetic reels.

The computer is not a creative machine. It does only what it is told, no more, no less. Furthermore, the user must address it in a certain kind of language. The computer is programed through artificial languages specially created for such purposes. Programing of computers today is less difficult than it was many years ago, but it remains a demanding and time-consuming task that calls for specialists. Programing represents an expensive part of operations, sometimes equaling that of hardware rental costs. A task that takes the computer a few seconds to complete may require many hours, weeks, months, or even years of program writing time. One of the problems related to the use of the computer in instruction is the fact that it is still very difficult in most cases for a teacher to modify computers without becoming a programing expert or without having immediate access to the expertise of a computer programer. Until such time as better programing languages are developed for the unique tasks of instruction and changes in program instructions can be accomplished with ease and speed by nonprograming specialists such as classroom teachers, computers will not lend themselves to flexible use in instruction to meet a variety of special pupil needs.

Various Instructional Modes of the Computer

The computer can be organized to assume various modes which are related to the purposes to be accomplished. If the purpose of the computer is simply to store or release information, it can be said that the computer is in the *information storage and retrieval mode*. In instructional applications this mode is employed in the management of records. It can entail storage of pupil test scores and marks and retrieval of past performance information. The teacher addresses the computer to yield data on mean scores, distributions, or other types of test score analyses by pushing the correct sequence of buttons. The data retrieved may be displayed on a small TV monitor (cathode ray tube) or may be printed out on special paper. In some cases, the teacher addresses the computer and receives responses on a teletype.

Closely related to the above mode is the *testing and scoring mode*. Test questions may be presented to the student via some computer-activated device, and scoring is done on the computer. This approach is a variation of testing by having students mark special answer sheets with an appropriate pencil so that the computer can automatically process the results.

When the computer is programed to solve problems it is

said to be in the *problem-solving mode.* Thus, a teacher or an administrator may direct the computer to compute the class mean on a given test or the average grade on tests over a given period of time for one or more pupils. The computer is queried; the data stored within are manipulated according to the computer program; and the answer is delivered as output. The problem-solving mode is coupled with the data storage and retrieval configuration. It is distinguished by the fact that data are processed or organized in a particular way to solve some problem.

The most intriguing configuration, as far as this report is concerned, is what is called the *tutorial or instructional mode* of the computer. It calls for the design of hardware with special capabilities and a unique computer program to facilitate learning. There are two distinct types of input-output arrangements in the tutorial mode. The computer may be addressed and responses recorded via a teletype. In this input-output arrangement, the student types his replies to questions received from a teletype machine. To illustrate, the student may be directed to find the sum of 2+4. If the student responds by pressing the number 6 key on the teletype, the computer reacts by printing out the word *correct.* The computer then activates the teletype to print the next question. The teletype operates at a relatively slow pace. Typing is not a natural or usual mode for the pupil at this time.

A second input-output display of questions is through what looks like a small TV and is called the cathode ray tube (CRT). In this tutorial mode the pupil is presented with a multiple choice question displayed on the small TV screen. The computer is programed to present a problem, such as the following, on the screen:

$6 + 4$ is the same as $5 + 5$
True False

The student uses the unique "light pen" to touch the square next to the word of his choice. The touch of the light pen on the square activates a signal to the computer. If the square next to "True" is touched, the computer responds by presenting the word *correct* on the TV screen.

The tutorial mode of the computer may be subdivided further by types of learning activity. Computer-assisted instruction (to be called CAI henceforth) may emphasize a drill-and-practice mode, author mode, dialogue mode, or the simulation or gaming mode.

In the *drill-and-practice mode,* the learning activity may be a mathematical process that calls for a correct response to many variations of the process. It is a repetitive activity, continued until student responses as recorded by the computer demon-

strate attainment of a specified level of competence.

In the *author mode*, the learning activity involves the computer's generating words or numbers which the student puts together in sentence form or in a formula. The computer compares the sentence or formula organized by the student with all possible answers stored and programed within it.

The *dialogue mode* allows the student to interact with the computer. In other words, when presented with a problem, the student may desire additional data before responding. This mode allows the student to interrogate the computer in attempting to resolve the problem situation.

The *simulation or gaming mode* is the most sophisticated of the instruction-related modes of the computer. The problem is a simulated real world situation and the pupil is forced to select the most appropriate course of action. It is an extension of the dialogue mode, for the student can ask questions and is given immediate feedback on the consequences of any decision made. A decision leads to a series of consequences calling for still other decisions, some of which may have undesirable results. The same mode can be based on management decision or marketing games.

Systems

For the computer to reach its full potential, an integrated man-machine approach is necessary. The productive application of hardware to meaningful tasks depends on the software or computer programs designed by men. The situation, the machine, the program, and the results must be seen as an interrelated or unified system. Systems is an important concept in any arrangement of which the computer is a part. "Systems" carries special connotations among EDP specialists. It has assumed an almost sacred position. To computer men, systems implies taking a total and systematic look at related operations in the hope of discovering a unified approach to efficient operation in a particular situation. No single activity can have meaning standing alone and unrelated to the objectives of the organization.

In a more precise sense, a system is an array of resources designed and dedicated to achieve an objective according to some plan of action. Stated another way, it is an arrangement of resources to focus on goals in an optimum fashion. Its opposite would be disjointed or unrelated efforts, ineffective utilization of resources to achieve a mission. The systems approach in any field demands that objectives be determined, after which a plan is developed to reach the goals with the most efficient use of resources. Because there is a system of interrelated elements, change in any one element will upset balances and relations with all others. A working computer opera-

tion is one illustration of a complex man–machine system. The problems in adapting a computer system to instructional purposes go far beyond simply leasing or purchasing a machine. This may be the most costly part, but other considerations in involving the computer in education often prove far more perplexing. In particular, the development of software or the translation of existing subject matter into computer format represents the most difficult dimension and is likely to delay the more complete involvement of the computer in instruction.

Computer Generations

The computer is based on a relatively new technology; it is less than 30 years old. Nonetheless, in this short period of time at least three generations of computers have been produced. In this fertile field, the fourth and fifth generations appear to be in the offing. First-generation computers were very large, bulky pieces of equipment. They had to be housed in spaces of unusual size and with carefully controlled thermal environments. Humans grow larger as they mature, but computers reverse the process and become more compact. A dramatic reduction in size and a reduced need for careful regulation of temperature and humidity were made possible by the introduction of tiny transistors, which replaced large vacuum tubes. Transistors generate less heat; they are more reliable; and they permit new designs which provide larger internal storage capacity as well.

Third-generation equipment continues to rely on transistors, but the addition of integrated circuitry (printed electrical circuits of extremely small size) makes it possible to reduce the size of machinery even further while increasing internal storage and speed of operation. Third-generation computers have another unique advantage of special interest to educators. A number of remote input-output terminals (devices to insert or retrieve data) can be plugged into the main computer, which is located a considerable distance away. This means that important computer controls and visual display units can be placed in classrooms and libraries. This capability existed in some second-generation equipment, but relatively few remote terminals could be supported by the main processing unit. The full potential of CAI is more likely to be realized through the utilization of third-generation equipment, which permits greater decentralization of remote input-output terminals. One or more remote terminals in any school classroom and library is a distinct possibility in the years ahead.

Computer-Assisted and Computer-Managed Instruction

There is some evidence that the computer can be harnessed to direct instruction of pupils or to the tasks of managing and

processing data generated in the teaching-learning process, counseling, and scheduling. The many field visits over several years by the AASA Committee on Technology and Instruction reinforced its conclusion that computer-assisted and computer-managed instruction can most accurately be described at this point as emerging from the laboratory stage. Once again agreement is noted with the federal Commission that reported that only primitive software is available and that there are fewer than 1,000 computer-assisted terminals serving fewer than 20,000 public school students.[2] There are many well-developed non-instructional computer applications in operation in schools across the nation. The fact remains, however, that computer-based instructional packages are not available in most curriculum fields.

There are many significant experiments being performed in various school centers in the East and West, North and South. It must be emphasized that they are experiments aimed at perfecting an approach and adapting instructional material to computer operations. New York City has 200 terminals in 16 schools with an annual operating cost of about $1 million a year. The Philadelphia, Pennsylvania, public schools have the most comprehensive system of computer utilization in operation that was observed by the Committee. The many options in Philadelphia involve elementary, junior high, and senior high pupils. In grades 8 and 9 the goal is computer literacy, learning about the computer. Rudimentary computer programing was the target at the fourth and fifth grade level, although the desirability of introducing the computer at this low a grade level is now being questioned. Philadelphia high school math and science pupils use the computer to solve problems. The vocationally oriented view the computer as machines to be operated, maintained, and repaired. To complete the Philadelphia package the computer is used as a medium of instruction, that is, in CAI format or as an actual teaching-learning tool. The externally funded and district outlays for the comprehensive computer involvement in various instructional purposes in Philadelphia approach $1.5 million annually to serve about 43,000 students guided by a special computer-oriented professional staff of about 42 people. The professional staff has developed or is engaged in the development of course materials in biology, reading, and IPI math as well as some gaming and similation.

Not all advocates of CAI have tempered their claims to be consistent with the findings of research. Most demonstrate the feasibility of CAI without proving it to be the most effective or economical means. There is some concern that attempts to implement CAI in all schools before it is fully developed or prior to demonstration that it can significantly improve learning may generate a backlash that could delay realization of the full po-

tential inherent in CAI for many years.

CAI depends on something more than a machine. The computer program is a reflection of a theory of how learning is best stimulated. If the program has a valid theoretical underpinning—that is, accurately reflects how the human being at various stages of development most effectively learns—then the machine will have a contribution to make. Some argue that CAI has no conceptional base per se in the learning process. The machine is less important than the programed instruction to be activated by the computer. It should be recalled that electronics experts developed the computer. The contributions of the electronics expert, who knows the capabilities of the computer, must be merged with those of the expert in learning, who knows how to sequence experiences to maximize learning. It is suggested that "teacher-assisted" computers are necessary before the maximum potential can be derived from the new instructional technology.

Problems and Issues in CAI

The computer was invented to serve the complex computational needs of scientists. It began as a research tool. Its creators were, by and large, unconcerned with educational problems. One of the several challenges facing educators in this field was how to adapt an instrument designed for someone else's problems. The scientist wanted rapid calculation of complex mathematical equations. In education, the emphasis is on large storage capabilities rather than speedy computation. The continuing evolution of hardware made possible a computer configuration to meet educational needs. Third-generation computers with large internal memories or storage, very fast response, relatively simpler programing procedures, and provision for several remote input-output terminals connected to the central processing unit greatly enhanced the probability of applying this modern marvel to the problems of education.

Third-generation hardware with remote input-output terminals makes CAI more feasible, from a technical viewpoint, than ever before. To repeat, computer characteristics represent only one dimension of a complex problem. There is agreement among authorities that the software (the instructional program in this case) is the key variable. The quality of CAI will be determined in large part by the quality of materials inserted into the computer and activated by the computer to stimulate learning. In this sense, the computer hardware is the support system for the learning activities. CAI demands new skills to generate computer-compatible instructional programs. A great deal of time will be required to translate knowledge and skills presently organized in formats that are incompatible with computer operations into machine-usable forms. A 1966 *Fortune* magazine

article entitled "Technology Is Knocking at the Schoolhouse Door"[3] declared: "The software for a computer-assisted instructional system does not yet exist; indeed, no one yet knows how to go about producing it." Relatively little progress has been made since 1966. Only a handful of school systems as late as 1970 had much more than limited drill-and-practice exercises for a few elementary grades. The Committee found one school district, the city of Philadelphia, which had a complete one-semester course in biology and another in reading in CAI format. This was in operation in two high schools and two junior high schools, but the program lacked an audio component. Stanford University in 1968 had a computer network supplying instructional materials to 32 schools across the country, but only about 1,000 pupils were served with drill-and-practice and reading exercises. The Stanford work in CAI under the direction of Suppes traces its beginnings to 1961. The earliest planning activities for computer-based teaching date from 1958.

One source estimates that 300 hours of preparation are necessary to produce enough material to keep a student productively occupied for a one-hour period at a CAI terminal. Another writer, on the basis of accumulated experience, reports that 100 hours of analysis, programing, and editing time are required to produce one hour of CAI material for a student.[4]

For the purposes of further analysis, assume the shorter period of 100 hours of preparation for one hour of CAI learning time. This means 500 hours to yield enough CAI materials to keep a student occupied productively with CAI for only one school day, assuming five hours therein. At this rate, 2,500 hours of preparation should produce enough exercise for only one week of student involvement all day long with CAI. Assuming that a teacher works a 40-hour week, he would labor about 62 weeks to produce enough material in CAI format to keep a student occupied for one week. Stated another way, and assuming a 36-week school year, the teacher would devote almost a year and three-quarters to plan one week of student involvement in CAI. Another source computed the time it took those in the CAI experiments to produce 234,000 exercises for mathematical drills that occupied 268 students only five minutes a day for 160 days in the school year. It required 1,000 man-hours to develop relatively simple CAI materials for teletype terminals which had no audio or television terminal display capability.[5] It is apparent that the time required to produce CAI materials greatly exceeds what teachers have reasonably available for planning educational activity. In terms of dollars, it may vary from not less than $2,000 to a more likely $10,000 per hour of CAI instruction.

Someone other than a regular classroom teacher will have to

2

generate CAI materials for several reasons. There will have to be standardization (as textbooks have been standardized in the past) so the cost of production can be spread over a large number of teachers. CAI materials will grow obsolete just as textbooks do. There will have to be a policy of continuing revision, on at least a three- to five-year basis. The translation of existing educational materials into the CAI format will bring forth a new breed of specialists to supplement teacher activities. Such personnel must be granted the time and allocated the resources to produce CAI materials. The lack of such personnel and resources to date explains why at present CAI is characterized by bits and pieces of instructional experiences, primarily drill materials. (The Philadelphia city schools are the exception.)

In addition to translating the curriculum into computer-compatible format, a considerable investment in time and money must be made to reorient classroom teachers to new roles in the instructional process and to give them confidence and expertise in using CAI to enhance learning experiences. The prospect of multibillion dollar expenditures and multiyear (if not multidecade) investments in time should not be permitted to deter education from realizing the potential inherent in a developed system of CAI.

Economics of Adopting Two Technologies

The Committee on Economic Development (CED) asked a management consulting firm to investigate the costs to the nation's schools if two technological innovations, instructional television (ITV) and computer-assisted instruction (CAI), were adopted by the nation's public schools. It was not argued in the findings of this study[6] that either or both of the media should be implemented. Nor was it suggested how the additional costs could be met. The data that follow are based on the above-mentioned research, which represents the best information to date on the economics of adopting only two of the many marvelous technological innovations in public education.

The research completed at the request of CED focused on costs of installing ITV and CAI in the 16,000 public school districts wherein are enrolled 75 to 80 percent of the elementary and secondary school pupils in the country. A model school unit was designed for the purposes of the study; it was assumed to have 100,000 pupils in grades 1-12 and 152 school attendance centers (76 elementary and 76 secondary school units). Each attendance center had 24 classrooms (3,648 classrooms in the entire district) with 30 elementary pupils per classroom (720 per school) and 25 secondary school students per teacher (600 per school). Each school operated on one shift or a six-hour school day. It was further postulated that each student

would receive only *one hour per day* of ITV *or* CAI instruction, with 150 days of such supplemental instruction per year. Note that ITV and CAI were considered to be supplements rather than replacements, reinforcers of teacher efforts rather than substitutes. It was assumed further in the CED study that hardware purchased would be amortized on a 10-year basis. Of particular significance was the premise that centrally administered and distributed lesson materials would have a three-year life span.

ITV Costs

In late 1968, there were more than a thousand closed-circuit TV (CCTV) systems in operation in schools, medical centers, and industrial and military training centers. ITV includes the more familiar ETV stations whose broadcasts can be received on the home set and CCTV. Between ETV and CCTV is the 2,500 megahertz system (ITFS) located in the microwave portion of the broadcast frequency spectrum. Signal transmission in the megahertz band follows the line-of-sight path and can be distorted readily by obstacles encountered while traversing a given terrain.

A large item is the cost of producing ITV lessons; this can range from $50 to $500,000 per hour, including necessary labor and materials. The lower figure is based on the regular teacher (not one trained in TV techniques) presenting a lesson in front of a TV camera in a studio. The higher figure was computed on the basis of a contractual arrangement with commercial TV experts in mass communications and entails sophisticated and high-cost production. An illustration of the latter would be the writing and producing of a reenactment of an important historical event, such as the Battle of Gettysburg, for live TV or videotape. Should such a high-cost production prove to have wide appeal, it might be distributed with a videotape rental charge of about $55 per hour to other school districts. This could help offset costs. The study arrived at a production cost of $6,000 per hour for lessons produced by a specially trained instructor who concentrates on TV and has access to all the props, sets, graphics, and camera rehearsals necessary to produce high-quality TV lessons.

The special cost study of ITV assumed that each school would have as a minimum the following hardware: two 27″ black-and-white TV sets per classroom; six fixed videotape units; one portable videotape unit; one 4- to 6-channel receiver-converter; roof mounted antenna; and local distribution wiring. Each school district would have a studio and the components of a transmission system. Equipment maintenance was estimated at 10 percent and power costs at 1 percent of the total equipment costs.

The complete cost per 100,000 students in a school district would include hardware and software (production costs per hour). The estimated annual costs were computed to be no less than $800,000 for a closed-circuit microwave transmission, with $50 per hour production costs. The cost was estimated to be $3.2 million per year for a ground transmission ETV operation with $6,000 per hour production costs for software. The annual operating costs were computed to be $3.4 million for 100,000 students. Airborne transmission was the highest at $4.6 million.

School population density has an impact on costs. To illustrate, the land area of the state of Montana (with a total state school population of 168,000 students) exceeds the combined land area of New York, New Jersey, and Pennsylvania (with a three-state total of nearly 7 million students in school). ITV costs in Montana would range from $17.38 to $52.49 per student per year in contrast to $8.50 per student per year in the above three states. Costs per student hour of instruction would vary from 35¢ in Montana to 6¢ in the Mid-Atlantic states. This is many times higher than the 2¢ per student hour now being spent on conventional instructional materials. The largest single cost item in ITV, in all but the $50-per-hour software production category, is instructional lesson production, not equipment or operations.

CAI Costs

The electronic digital computer can be a powerful teaching tool, and its cost may be commensurate with its power. The Booz, Allen, and Hamilton study completed at the request of CED assumed that one terminal could serve six students a day, since only one hour a day of CAI would be available to a student. In the hypothetical district of 100,000 students, some 16,700 terminals would be required to serve the students. In addition, 1,800 hours of CAI programing were estimated as necessary. This is a conservative estimate and is based on one hour of programing a day for 150 days for each of 12 grade levels. About 600 hours of CAI would have to be rewritten annually if the life span of CAI is estimated to be 3 years.

It was estimated that one central processing unit (CPU), or computer, could serve 200 remote input-output terminals employed in the drill-and-practice mode. This means that the model school district with 16,700 terminals would need 84 computers! Contrast this with the fact that very few school districts have even one computer today. (In 1966, about 800 districts had a computer; in 1970, the number had doubled to 1,600.) A fully implemented CAI system would require multiple computer installations. Few have yet recognized the hardware demands of instructional technology. The hardware costs alone

for a complete CAI system would total $40 million annually. Mass production could reduce the cost of computers by 50 percent, to about $20 million annually. Software for the drill-and-practice mode of CAI—that is, the computer programing costs—would total about $765,000 annually. To this must be added $6,400,000 for personnel, supplies, utilities, and so forth. Assuming hardware costs based on mass produced CPU's, the total cost for one hour per day per student for drill and practice on a computer would be $27.2 million in a 100,000-pupil district. The effects of inflation were not taken into account in the 1968 study.

The more sophisticated tutorial mode in programed instruction would revise the ratio downward so that one CPU could serve only 32 remote terminals, as opposed to 200 terminals for the drill-and-practice mode. In other words, more than six times the number of computers used in drill and practice would be needed in the more sophisticated tutorial mode. The 520 CPU's necessary to handle the tutorial mode for 100,000 pupils would entail an estimated annual rental fee of $100,200,000 at 1968 prices. A 50 percent reduction in price because of mass production would bring the hardware costs for the more elaborate instructional configuration to about $50 million annually for the model pupil district. Programing costs would also be higher—about $4,600,000 annually. The additional personnel, training, consultants, supplies, and so forth would require another $17.2 million annually. The total cost for the tutorial mode was estimated at $71.8 million annually for a 100,000-pupil district.

The smaller the district, the higher the cost per student per hour on CAI. In a 10,000-pupil district, the cost per student per CAI hour would be $2.27 in the drill-and-practice mode and $7.53 in the more sophisticated tutorial mode. Analogous figures for a 100,000-pupil district are $1.81 and $4.79 respectively; for a 500,000-pupil district, $1.77 and $4.27 respectively.

To serve 75 percent of the nation's children, the total cost in 1968 prices for the drill-and-practice mode would be $9 billion; for the tutorial mode $24 billion. Implementation of sophisticated technology is not cheap. The cost of adopting only the two technologies of ITV and CAI would be at least equal to the total cost of education in 1968. The study which CED authorized pointed out that "these additional costs would probably require a major change in the present system of financing American education."

Combined ITV and CAI

The economics of implementing new systems of instruction place the whole matter of technology and instruction in a unique perspective. This is apart from any arguments as to

whether there are any hard data that indicate that pupils learn more, better, and faster with ITV and CAI than they do with conventional modes of instruction. Alternative approaches to instruction cannot be ignored, especially in view of financial considerations. The CED study noted: "On the basis of present anticipated costs, the financial investment required to install and operate instructional television and computer-assisted instruction will restrict significant use of these instructional media." However, high costs do not necessarily make inevitable abandonment of a promising technology for purposes of instruction. Realistic appraisals may be used to indicate the additional support which public education needs to broaden its technological capital base. The appraisals may also suggest that resistance to newer instructional technologies results from economic constraints placed upon schools, as well as from the conservative bias of some professional personnel.

The U.S. educational system must struggle hard to obtain additional funds from state and local sources to cope with growing enrollments, obsolete facilities, rising expectations, and new curriculum demands. It is somewhat unreasonable to expect the same financial base to provide additional revenues to pay CAI development costs. It is apparent that federal support for the development of CAI materials and investments by the computer industry will be necessary to produce the needed software and hardware. The total of federal CAI research and development grants was less than $25 million during the 1960's. Progress in adapting computer technology to education will require annual investments of 100 times that amount in the 1970's. A whole new series of organizations formed for the specific purpose of producing curriculum materials for CAI courses are springing up. The rate of development will be influenced strongly by the magnitude of funds. It is difficult to accurately determine investments in CAI by private industry. It is now clear that some industrial giants grossly underestimated CAI development costs and as a result are showing signs of retrenching. One large firm is reputed to have invested over $100 million in CAI and failed to produce a marketable CAI instructional system as yet. CAI is not a get-rich-quick bonanza even though the possibility of a multibillion dollar education market exists. It will take decades for industry to reach a break-even point on its investment in CAI.

CAI is merely one of a number of alternative approaches to instruction. Most experiments demonstrate the feasibility of presenting instructional materials in the CAI format, but comparatively little research has shown whether it is a *better* way to stimulate learning or whether it is a *less expensive* way to develop certain skills and insights. It remains to be proved experimentally that CAI is superior to all other approaches.

Comparative Costs of Alternative Systems

The cost factor in implementing technology is a matter of prime consideration along with the scarcity of software and the general lack of programs and time for the retraining of instructional personnel in the effective utilization of the new technology. The installation and operating costs may be reduced by greater utilization of equipment, by increasing the speed at which a student learns a set of concepts or skills, by redesigning equipment to serve specific educational purposes and other means. Costs vary and cannot be comprehended in isolation, that is, without a standard of comparison for alternative approaches. Cost analysis should not be equated with cost-effectiveness or cost-utility.

A rather detailed description of the costs of ITV and CAI was presented earlier. At the present time no more than 4 percent of per-pupil expenditures in the public schools in any year is dedicated to all types of instructional materials, that is, the new and the old, the pedestrian and the sophisticated. The federal Commission presented the following to show the wide cost variations for instructional equipment: [7]

About $700 can buy a 16-mm film projector.

Fifty to sixty thousand dollars can cover the initial cost of a dial-access information system in a college or university, but costs can run into the hundreds of thousands.

On the average, a closed-circuit television system costs $178,000 to install, and can be operated for $86,000 per year.

Nine self-instructional units of a physiology course developed and produced at Michigan State University, making use of carrels, audio tapes, slides, 8mm films and programed texts, cost $40,000.

The high school physics course produced by the Physical Sciences Study Committee (PSSC) cost $6.5 million.

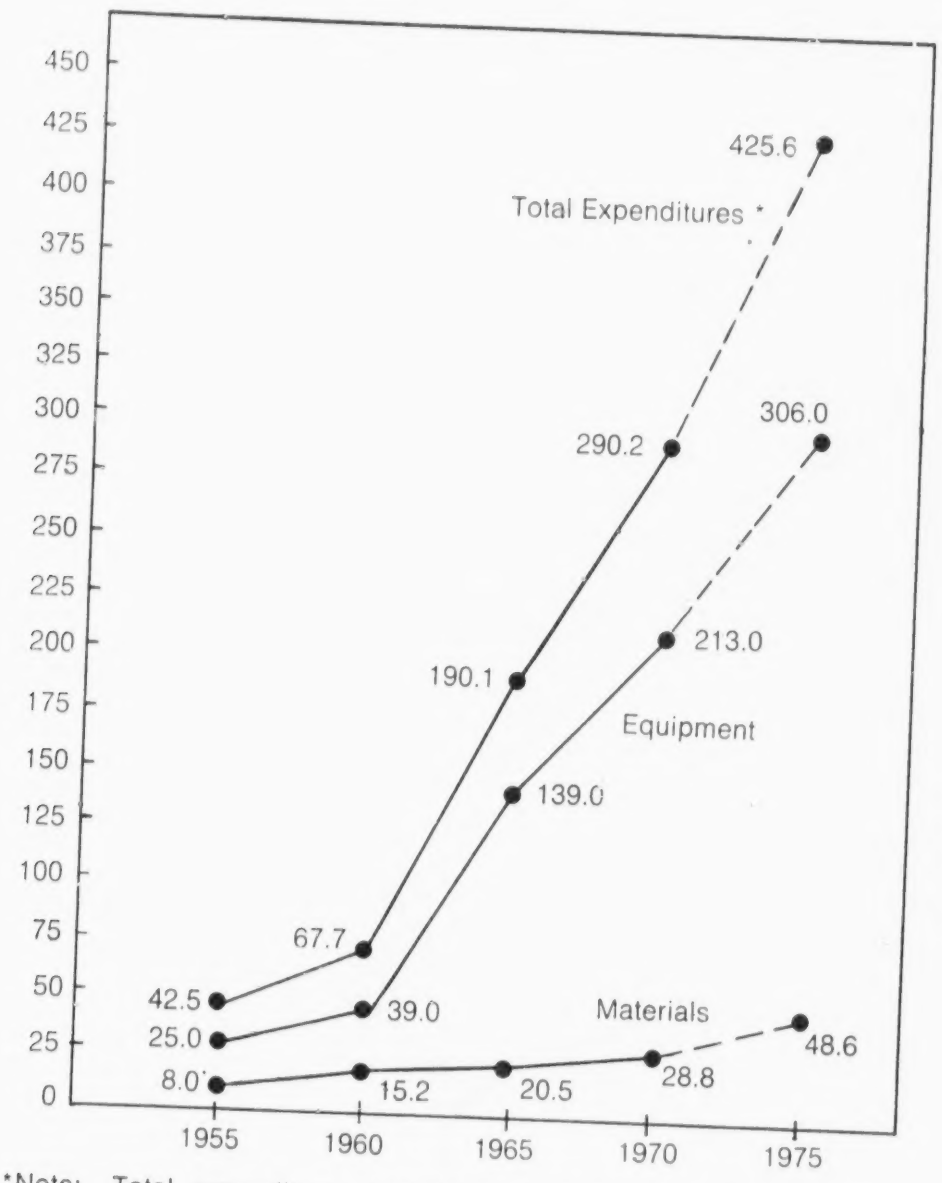
The Midwest Program on Airborne Television Instruction cost $18 million for the period 1961-65.

A simple televised lecture can be produced for as little as $50 an hour, while a presentation making use of film and other visual materials might cost as much as $6,000 an hour.

The rapid rise in expenditures for AV equipment and materials is evident from Figure III.[8] One very large junior college system with a comprehensive and sophisticated instructional resources center reported to the Committee expenditures ranging from 6 percent to 9 percent of the total junior college budget to purchase equipment, to produce instructional support materials, and to administer the center. In some years this came to almost $2 million. Instructional support services are not inexpensive.

Figure III

Expenditures for Audiovisual Equipment and Materials by Elementary and Secondary Schools - 1955 to 1970 (with projections to 1975)



*Note: Total expenditures include equipment and materials plus other items such as maintenance and general overhead. Totals are probably low, but trend is indicative of recent developments. Data do not include computers or programed textbooks, but do include radio and television.

Source: U.S. Office of Education

Current Status of CAI

At the present time, there is no CAI system that can compete with the live teacher. However, with increasing salaries for instructional personnel and the likelihood of decreasing costs in the utilization of sophisticated instructional gear, such as computer-assisted devices, a crossover point may occur. Economic analysis suggests that sometime prior to 1985 an important point will be reached where the cost of traditional instruction with a live teacher (teacher-assisted instruction) will rise to intersect the declining cost curve for sophisticated instructional systems, such as CAI. More will be said about this in Chapter 5.

In the late 1960's the AASA Committee on Technology and Instruction observed that computer-assisted instructional devices were in the embryonic stage. It was demonstrated that information in the form of drills and other learning activities could be presented to pupils on a computer-activated cathode ray tube. Relatively little data were generated during the 1960's as to what types of pupils learn more via CAI and what kind of instructional concerns are presented best by CAI. The "individualization" which CAI provides is better defined as individualized pacing, with some degree of branching to provide additional exercises for those who need it. It is not individualization in the sense of using the instructional strategy that is most appropriate to the talents, interests, or background of the learner.

Presenting a question and answer on the cathode ray tube may not be much different from presenting them on a piece of paper. Perhaps by 1985 all aspects of the curriculum will have been programed into machine-usable form. It is very likely that by that time the computer will have assumed much of the burden of classroom management in such areas as pupil progress reporting, attendance and general information keeping, and other record keeping. The teacher will feed inputs, such as personal and instructional data, into the school's computer via a remote input-output console located in the classroom. The teacher will use the same console to retrieve data or reports almost instantaneously. Other computer consoles will be reserved for pupil use in drills, exercises, or exploration experiences.

A considerable amount of glamour surrounds CAI, and it is not the purpose of this report to detract from it. We recognize, however, that unwarranted claims or premature adoption may generate backlash. It is only recently that writers have begun to suggest the need for a moratorium on promises not yet supported by facts. Writers are also stressing that criteria should be determined to describe the limitations as well as the reasonable expectations of the research efforts in CAI. Computer-

assisted instruction, or the laser-assisted instruction of the future, has too much potential to be sidetracked because its more enthusiastic proponents make unwarranted claims which it will fail to meet, thereby disappointing where it might have amazed.

There are published periodic reports on the status of CAI experimentation and other activities. ENTELEK described the software, hardware, comouter languages, and secondary school applications of CAI in various regions of the U.S. in 1968-69. This was based on the statements made by over 160 CAI specialists.[9] The U.S. Office of Education reports the CAI research it supports as well.

Footnotes

1. American Association of School Administrators. *EDP and the School Administrators*. Washington, D.C.: the Association, 1968.
2. Commission on Instructional Technology. *To Improve Learning*. A Report to the President and the Congress of the United States. Washington, D.C.: Government Printing Office, 1970. p. 76.
3. Silberman, C. E. "Technology Is Knocking at the Schoolhouse Door." *Fortune* 74:120-25; August 1966.
4. Rogers, James L. "Current Problems in CAI." *Datamation*, September 1968. pp. 28-33.
5. Hagen, Enoch. "CAI: A Commencement." *Business Automation*, November 1967. pp. 49-53.
6. Booz, Allen, and Hamilton. *Costs of Installing and Operating Instructional Television and Computer-Assisted Instruction in the Public Schools*. Chicago: Booz, Allen, and Hamilton, 1968. 19 pp.
7. Commission on Instructional Technology, *op. cit.* p. 86.
8. *Ibid*, p. 67.
9. ENTELEK CAI/CMI Information Exchange. *Computer-Assisted Instruction, North/South/East/West*. The Proceedings of Four Regional Conferences, Newburyport, Mass.: ENTELEK, Inc., 1969. 28 pp.

4. Instructional Technology: Learning Impacts and Bypasses

The computer is acknowledged in preceding chapters as an educative device. Many other technological devices offer dramatic possibilities for assisting the school in its central task of teaching. The primary factor in considering the application of any device to schools is whether its enhances, thwarts, or bypasses educational development. Initial and continuing costs, as outlined in the previous chapter, also are sobering thoughts for those who must make decisions about the commitment of resources to support the various missions of a school system. The hardware of instruction has a considerable fascination for the public, and some administrators are tempted to win the public's regard by appealing to this fascination. However, the romance that surrounds such devices ends for the school administrator when expectations fail to materialize, problems continue unabated, and cost overruns abound. The superintendent, particularly, must seek to establish criteria and priorities for acceptance and support of new approaches to school system operations. The acquisition of gadgetry must not be permitted to outrank in importance the improvement of learning.

Teachers engrossed in teaching, administrators concerned with maintaining an organizational sense of unity, researchers occupied with new discoveries, and manufacturers engaged in producing hardward and increasing market penetration for equipment—all these ostensibly share a common goal called "progress." However, everyone is doing his own thing. Working in splendid isolation may foster the widely publicized gap between the theoretician and the practitioner. The enterprising developer and vendor of educational devices rides forth with high hopes that his economic gain and educational progress

always will coincide. As a matter of fact, all categories of persons listed above have a "positive result fixation." Unfortunately, this apparently happy situation prevails only if a certain erroneous assumption is made. Only if we assume that no one interest is antagonistic to any other interest can we retain our optimism.

Each person with a unique interest in education undoubtedly has a keen desire to further the learning opportunities of youth. The major problem is that each one has been left primarily to his own devices in developing a particular contribution to the teaching-learning situation—that is, in generating new methods and sharing with others the important task of instruction.

The major requirement now is for a catalytic agent to bring together people with unique contributions into a unified effort. The superintendent of schools is the most logical person to serve as that catalyst. It is impossible for any one person to master all of the technologies that are required to provide a well-rounded educational program. The superintendent is not presumed to be such a master. His unique contribution is in knowing how to recognize the worth of learning facilities and to provide support and direction for those manning such facilities. If effectiveness is contingent upon bringing together in a systematic way the necessary persons and facilities, the superintendent must find ways to expedite this union. The promoters of the various technologies adapted to instructional challenges maintain, more often by implication than direct declaration, that human learning is accomplished best by following specified procedures. It is the responsibility of the administrator to ferret out the conceptualization of learning that underlies a given machine configuration. This is not an easy task. It is important that administrators review the multiple definitions of learning once again to have a basis for appraising technologies for instruction.

This publication will not catalog the tasks that are to be performed by the administrator in managing the schools' posture vis-à-vis technological developments. Rather, it will attempt to stimulate total school staffs to think about the right problems and possibilities as technology, teaching, and learning are cast into new relationships.

Multiple Definitions of Learning

Learning has been defined in many ways. There are traditional definitions with many variations which stimulate discussions, arguments, and resolutions among theoreticians and practitioners. Some definers apply a technology of logic in what may be termed a modern attack upon the definition of the phenomena of learning. Hazarding oversimplification here—but doing so for the purpose of this discussion—learning can be

considered as the individual's response to old or new stimuli in the environment in old or new ways. If an existing characteristic in the environment stimulates a person to perform only in the usual way, learning has not taken place; that is, no unique or new behavior forms are evident. On the other hand, if an old item in the environment stimulates the learner to a new way of behaving, learning *has* occurred. The more exciting view of learning in this fast-changing world is that because of learning people respond to new elements in the environment with new ways of behaving. Much of the application of modern technology to the teaching-learning process is aimed at producing certain behavioral outcomes.

Learning occurs as the individual interacts with his environment in unique ways. The teacher is a third factor in the process. Through the act called teaching he may arrange the environment in such ways as to increase the probability that the learner will be stimulated to find new manners of behaving. Teaching and learning may be perceived as two sides of the same coin.

The teaching process may be viewed as the interaction between teacher, learner, and the environment—or behavioral engineering. This means that teachers are engaging in efforts to structure an environment in such a way that the students will respond in an anticipated or predetermined way. Environment includes all of the physical and nonphysical elements that can be involved in pupil interactions and reactions. The environment or learning situation, for sake of simplicity, can be called the classroom. There are two major elements in behavioral engineering. One is the technology of controlling the elements in the environment that stimulate learning and the other is the technology of making the response to stimuli so exciting that the learner wants more stimuli.

Along with some skills as contingency managers, teachers have understood many elements of stimulus control. Those with greater understanding of stimulus controls are in a better position to shape student responses to a predetermined pattern. The old gold-star system was called "external" reward and was vilified. It appears to be winning new favor in stimulating learning among those from low socioeconomic areas who experience learning problems. Many other ways of reinforcing have been developed. Technological teaching devices of many varieties are available for reinforcing learning.

Central Position of Learning

Few would debate that learning is the focal purpose for creating and maintaining a school. This means that were there no pupils in the schools, the teachers would have no function. The primacy of learning as the single, dominant purpose of

schools must be borne in mind in discussions about technology and learning. This seemingly obvious observation is not as easy to maintain as it first appears to be. The difficulty in maintaining learning as a central focus is alternately the responsibility of educators and laymen who suggest new functions for education. Deviations from learning activities as the major purpose of the schools are rationalized on the grounds of their importance to the pupil's health, social welfare, national security, or spiritual needs. Pupil services such as mid-morning milk, lunches, transportation, recreation, and entertainment are defensible school-sponsored activities but, nevertheless, they interrupt the teaching function. This may be justified in areas where large numbers of underprivileged children come to school hungry and malnourished. These children cannot learn if certain basic nutritional needs are not satisfied. Claims that pupils learn important things in the cafeteria, at the school dance, and on the athletic field have some validity, but by no means can this be twisted to mean that the curricular or instructional processes have been overemphasized as the central purpose of the school.

At times it may be difficult to maintain learning as the central focus because of the competition for attention among more peripheral concerns and supporting services. The special pleaders in the school environment present strong pressures for related services, but their sponsorship does not signify necessarily that they want to displace instruction. There is a continuing responsibility to sift through the pressures and to weigh their relative merits. When accepting responsibility beyond the instructional function, schools must justify the decision by demonstrating that all aspects of service are enhanced. But this is often difficult to do. The schools, for instance, have some responsibility for reducing or neutralizing many of the factors that lead to delinquency. Therefore, they often are forced beyond instructional responsibilities to certain police functions. The budgetary support and staff energy diverted from the improvement of the basic instructional program may lead to a critical imbalance in school services.

Many Facets of Learning

Luckily for modern youth, the old and faded belief that "learning is good learning when the pupil hates to learn" is long gone. The corollary was that "it doesn't make any difference who teaches you so long as you hate the teacher." We have gone through much change since those unhappy days of sadistic pedagogy. During the heyday of Progressive Education, much emphasis was placed on the *happiness* in learning, which was to be achieved in many different ways. The residue of the decades of Progressive Education's influence is still with

us, but often it is not associated with its origin. More important, perhaps, is the fact that information coming from researchers and developers helps teachers to recognize and master the various means of reinforcement to learning.

More attention in recent years has been given to the different kinds of learning with which the teacher is confronted in the classroom, particularly strategies for individualizing instruction. Discussants of learning types and processes often glibly invoke theories of learning in support of particular approaches. Even general and vague references to theory seem calculated to calm the fears of those faced with making decisions on accepting technological hardware and adopting various plans. However, professional educators need and are justified in demanding adequate research data with which to make judgments about the theoretical substance of current technology. It is unfair to ask teachers to perform as ill-informed wizards. Professional researchers must recognize that instead of being long on debate and short on research they must reverse their allocations of effort.

The tendency to treat the concept of "theory" in a blindly worshipful manner has befogged the important and original purpose of the term. Indeed, the acquisition and use of specific items of educational technology may involve reference to a theory of learning, but to consider this as theory adoption is in most instances a misuse of the concept. *Theory* is an orderly and systematic way of "arranging in relationship" the elements or variables in an area of inquiry or projected operation. However, in arriving at theories many people fail to identify the assumptions, known facts, and speculations in selecting and arranging elements or variables. Such "logical" relationships are determined in large part by value judgments. It is quite obvious that the theoretical base for any technological adoption in the schools may be challenged at will. Identifying the underlying theory of learning, then, may not prove to be as useful a criterion for administrative decisions about instructional technology as one would first hope. But if supporting theories and their underlying assumptions are made clear, decision makers have something to work with in assessing the potential of the instructional innovations in question for meeting certain principles of learning.

The abrupt shift from the relatively unstable basis of theory (of teaching or learning) to the more objective question of principles in this discussion may suggest that one simply turns off the one and turns on the other. Such oversimplification is not intended. In fact, the trail from theory, through research and operational models and data gathering and interpretation, to field trials and verification is a long one. Yet, sound principles seldom are established any other way. The shift from theory

to principle as a vehicle for decision support is essential for practical reasons. Administrators and staff personnel need valid criteria more than open-ended theory to make decisions of prime consequence to the instructional program. Principles, well-supported by the evidence of research, constitute a much better basis for making decisions.

No effort will be made to enumerate or to defend the total array of principles related to teaching and learning. Other publications will supply such information. An illustration of the utilization of one specific principle of learning must suffice for the purposes of this book.

The effectiveness of motivation as a means of increasing the success of teaching and learning efforts long has been recognized as a principle of education. The theories and models underlying this time-honored principle are many and are still subject to periodic review and debate. Hence, it is a useful principle to use by way of illustration.

A decision about the introduction of computer-assisted instruction, a language laboratory, an instructional resources center, or a multimedia center should involve the development of criteria by which the best judgment might be assured. The *motivational* potential of any device under consideration is a high priority criterion. School administrators properly might raise a number of "motivation" questions that should be answered before making the commitment to innovate. Questions like the following are appropriate:

1. Does the loss of person-to-person competitiveness for the student-in-a-booth detract from motivation?
2. When the newness or novelty of a gadget wears off, what motivating qualities persist?
3. Will increasing pupil-machine interaction decrease motivation to improve skills in human relationships?
4. How much motivation to become independent fact finders will be lost through the facilities of push-button resource centers?
5. Will multimedia presentations develop sensory conflicts or blocks that result in a dulling of the individual's motivation to learn?

Many more questions might be posed. No one person in a school system is expected to answer all of them. The administrators, however, are responsible for seeing that all such questions are answered satisfactorily before committing school resources to the acquisition or establishment of a technological or any other type of facility. The answers to questions can be supplied by special staff, teachers, research and development centers, manufacturers, vendors, or a host of other sources.

But answers there must be. And the answers must be evidence-based as opposed to off-the-cuff opinions of legitimate experts or self-appointed soothsayers. Without clear-cut answers, isolation in a booth may be confused with individualization. Learning as a social process may come to be instead a series of electronically or mechanically regulated activities. The so-called teaching machines of the early 1960's generated an instructional fiasco in part because the appropriate questions were not raised about poorly developed but heavily promoted machines.

Recent teaching emphases have been closely bound to the stimulation of the types of learning classified as being part of the cognitive domain. Most of the testing procedures—particularly those based on homemade tests—are completely dependent on measurements at the lowest level in the sequence of types within the cognitive domain. The first efforts at programed learning, as well as the current ones with computers, focused sharply on the objectives of learning within the cognitive domain. The prime question still is whether this area of learning is better served by teacher-controlled methods or by teacher-supplemented methods that involve a substantial array of technological devices.

Research is not at all definitive at the present time as to whether one instructional system is better than the other. Much of the research on so-called technological devices has been devoted almost entirely to the *feasibility of use* rather than to the *quality of the outcomes* produced. The enormous task of holding back popular enthusiasm for change until there is sufficient evidence to justify moving ahead with the newer means of instruction presents a problem in judgment as well as in dollars. The corporate and independent researchers have reported at length on the impacts of technology on instruction, but the bypassed areas attract the attention of few authors or orators. Perhaps we can attribute this neglect to the personal satisfaction in the way of fame and fortune for those who work the "fertile valleys" of technology. Such people naturally resent activity that stirs up dust in the "neglected wastelands" of instructional advance through nontechnological developments. This chapter is an effort to register concern that both impacts *and* bypasses be weighed.

There has been much attention in the literature and in public address to educational objectives that are related to interest, attitudes, values, and appreciations. These elements often are recorded in lists of educational objectives, but the practitioners or researchers who can identify with great certainty the teaching or learning experiences that lead to the objectives in this domain are very few. There is no doubt that in recent years there have been better means of determining whether declared mis-

sions have been realized. As one looks at the technology of the present and the near past, it is somewhat of a task to identify those elements that have contributed to the achievement of learning in the affective domain. The sound motion picture and television seem to have been productive because of their ability to stimulate emotion. There is some indication that when the emotions are stimulated along with intellectual activity, learning is accelerated and is retained longer.

Very little information is available to indicate that the computer stimulates achievement of the objectives in the affective domain. As a matter of fact, some might conjecture that a pupil placed in a booth and confronted with only a typewriter and a television screen might experience some adverse effects in the affective area. Serious questions arise over some of the technological devices that are presented as positive and desirable contributions to pupil development because of their lack of attention to the affective domain.

At present, the developers of instructional technology are devoting little effort to the learning of manipulative or motor skills. Of course, provision for such learning is apparent in the form of equipment in the shop, typewriters in the business education department, laboratory facilities in the science rooms, as well as extracurricular activities involving such things as operating the auditorium stage and theater facilities. Therefore little of the current gadgetry in teaching seems to provide help in the psychomotor domain. (The fact that a student must hunt and peck his way on a typewriter in order to interact with a computer does not represent much of an opportunity for learning in the psychomotor domain.) The school again is confronted with the problem of balance in the instructional program. Pressures are exerted on all sides by the advocates of particular approaches. Interestingly enough, however, there has been little consolidation of attack among these areas of objectives by merchandising agents who serve the school with facilities and materials. School personnel, nonetheless, must design the school program to achieve a maximum balance among the various domains of objectives.

The development and merchandizing of instructional hardware do not resolve the problem of how technologically assisted learning takes place or how the teacher may arrange such hardware in order best to stimulate learning. At times, it is not clear whether instructional technology is seen as a way to increase the options available to teachers to stimulate learning, as a way to replace teachers, or as an end in itself.

The concepts of contingency management and stimulus control seem a helpful referent point in considering some instructional problems. One of the major tasks of administrators is to find and interpret the evidence relative to the claims of pro-

ponents of a new methodology. On occasion a person who has developed a unique method of instruction fails to devote the necessary time to extend its unique techniques or procedures because he spends his time keeping any competition from sharing the spotlight. Added to the complications are the facts that pupils represent a vast variety of abilities, backgrounds, interests, purposes, and strategies of personal change. There is no way to assure absolute correctness in decision making in all areas, but those who recognize the multiple facets of every decision related to instruction will make a higher percentage of wise decisions.

The simulator, one product of the technological era, may be used in the driver-training class to demonstrate that technology has assisted instruction. One also may note that in the cafeteria there are automatic devices which make food services more efficient. As the automation in such areas increases, more time may become available for designing new teaching efforts. The electric scoreboard is a technological device much appreciated by school athletes and fans alike, but one scarcely can say that technology of this type has been of much direct benefit to the school's instructional responsibilities.

The undesirable effects of any technological device probably have not been researched, and, if they have been researched, the information has not been released. Everyone knows that the X-ray is a wonderful device in the hands of the physician. The X-ray can focus on a minute area of the body and can assist the physician in his diagnosis and, ultimately, proper treatment. It is true, however, that overexposure to X-ray is harmful. The physician, then, must exercise controls against improper use of a device that, properly used, can give him great assistance. A physician can prescribe a pill which will enter the stomach of the patient. That pill seems to possess the magic of finding its way to the afflicted part of the body. When this is the case, we feel that the doctor is able to control this directionalism. However, when the medication runs wild and attacks other parts of the body, this control seems less apparent. This is the doctor's dilemma. Until he is reasonably well-satisfied with his knowledge of a drug and its influence on different parts of the body, he is likely not to use it. During recent Congressional investigations, however, it became evident that even the most erudite and highly ethical members of the medical profession have some problems in making sure that the technological devices that they use do not have adverse side effects.

School administrators and teachers are in a position similar to that of the medics, but they get far less help in protecting "clients" against improper effects. An instance of this is the use of computers in teaching. Computerized instruction has been researched for selected purposes and has been installed

in some schools. There are many lay and professional people who recognize only its magic and are demanding that all schools update by converting to computerized instruction.

Some proclaim that, ultimately, all education can be performed in the home. A television screen or other devices in the home will interact with a remote computer via an electronic communication system to manage the instruction of youth. The school staff is expected to make judgments and decisions with respect to such revolutionary ideas. Their task is considerably complicated when they must deal with those who see only the external magic and not the very real instructional problems.

Certainly there will be some conflict with the people in the school organization who feel threatened with displacement. In all probability, some large construction companies and architectural firms whose major business is the construction of school buildings will find electronic instruction in the home a threat to one of their great income potentials. It may be, then, that the threat of the loss of a market will spark a protest on the part of construction industries, which will find ways of insisting that the schools refuse dispersed instruction in the homes.

Some potential problems of home instruction by computer and television are much closer to the instructional responsibilities of schools than preserving economic opportunities for the architectural and building professions. A purely mechanical problem is represented in the variety of conditions under which people live. Some homes may be completely unfit, as is the case of those in the ghettos so vividly described in the public press. The school must not be expected to determine whether a given home environment is fit to serve as the educational environment of the pupil. A massive problem for school social workers and psychiatrists at the present time is to neutralize the effect of the home on pupils so that the desired learning can take place at school.

Still another potential problem is that of who controls education if it becomes generally computerized. The more centralized the dispensing of computerized instruction, the more centralized will become the control not only of the gadgetry, but also of the substance of education and eventually perhaps even of its purposes. The control of the substance of education must be the concern not only of school staffs but also of the entire population. An entire population is not easily swayed. Administrators, with much knowledge at hand and many communication devices available, still have difficulty in guarding against the threats to proper instruction, even when it is confined within the walls of one building. The problem is aggravated to unimaginable dimensions when that instruction is extended, through technology, to distant points.

Promises and Threats

The educational world is filled with people who speak in terms of fulfilling promises or resisting threats. Many are puzzled as to whether they should be concerned with these extremes or should seek analyses of the things that constitute the continuum between promise and threat. There are many important things to consider within these extremes. Many who make the promises and record the threats in dramatic form show a low or even a negative correlation between their knowledge of teaching and the instructional implication of their declarations. Those who communicate dramatically, no matter what the content of their communications, often are "exciters." Exciters under some conditions have a positive effect and under other conditions a negative one. Positive and negative connotations notwithstanding, the exciters stimulate and affect the "doers." These, in turn, have great influence upon the direction that teaching and learning shall take in the future.

Many changes in the educational program of this country have occurred, and, hopefully, changes leading to improvement will continue to occur. These changes usually reflect some response to contemporary life. They probably never can reflect contemporary life with complete accuracy because life is too varied and filled with contradictory elements. There are from time to time consolidations of positions that give school administrators clues as to what the supporting public may want. However, in making important decisions administrators must constantly assess whether such "consolidations" represent majority opinion or merely the effective promotion of an aggressive minority. Current school administration reflects contemporary life in its organizational and operational patterns, which show the influence of current business and industrial practices.

The schools of the future surely will reflect their times; teaching and learning will be affected. At the moment, it appears that a "cult of electronic magic" already is on the school's doorstep. This may be the force in the current environment that will most affect the teaching-learning arrangements of the future. There is little doubt that many other elements in contemporary life have made major impacts upon the learner and his learning.

On the distant horizon is a development that will concentrate on changing not the environment but, rather, the learner himself. If the chemical and pharmaceutical industries are successful in perfecting compounds now in the experimental stage, it is possible that the learning capacity and characteristics of learners can be altered. Just what this will mean to the schools is a matter of speculation at the present time. One thought that arises concerns the question of individualized instruction and learning through the use of technological devices. Individualiza-

tion may be of little import when pupils are equalized in learning capacity and speed by drugs.

The threats and promises of the moment are no more potent than the threats and promises of the past. Some alarmists probably were afraid that the invention of the chalkboard, which supplemented oral description with pictures and figures on the board, would cause the teacher to lose the skills of oral communication. That did not happen; the chalkboard, rather than detracting from the oral descriptive capacity, simply facilitated it. Sound films did not displace the teacher as some had predicted; rather, they intensified the impact of the total learning environment on the learner and made the teacher more effective. One current crop of activists declares that television at school as at home may destroy the development of library search skills. This probably will not happen; rather, the vividness of the new media as opposed to the printed page may stimulate search efforts. Once again, technology may be viewed as extending opportunities, opening new vistas, and increasing one's options, rather than simply upsetting delicate balances.

We must discriminate between "prophets of doom" and unthinking enthusiasts. The administrator, faced with all manner of alleged technological panaceas, must carefully consider both prescription and dosage if he is to properly accommodate his obligations both inside and outside the school.

There are organizations of competent people of good intent who are referred to by many practitioners in the field of education as "sophisticated deplorers" of the public school's environment. The pointedness of their publications and other statements has caused many educators to feel uncomfortable when confronted with their charges. While such persons are held in high respect, the educator is concerned that too often nothing other than personal opinions are presented. It is difficult to determine to what degree the position statements are undergirded by hard data that can stand the test of research verification. The fact remains, however, that their publications communicate very dramatically and effectively. Recent statements from these alarmist-type organizations show a concern for the loss of human values in educational outcomes that wholesale adoption of educational technology will entail.

Such concerns must be translated into specific day-to-day, minute-by-minute decisions, ranging from the kinds of equipment and facilities to be made available to the teacher and the pupil to the kind of environmental factors that can or should be controlled. Administrators cannot meet their control obligations by writing a book or giving a speech; theirs are the bruising, day-to-day, item-by-item decisions that must be made on the job.

The school, having made a commitment to certain tech-

nological developments, must make certain that the necessary staff skills are available or are developed. Too often, inside and/or outside pressures have led to purchases of an instructional gadget which teachers were incapable of using or unwilling to learn to use. Of perhaps greater importance than providing competent people is keeping the technological devices out of the hands of incompetents. Many promising instructional procedures have been discarded for no reason other than the fact that they fell into the hands of incompetents. It is a function of good management to prevent incompetence and its outcomes.

Superintendent as Prime Realist

School personnel may be saddened by the history of education and may dream excitedly of the days to come, but there are few who can afford the luxury of such reveries while the educational world is demanding attention to the processes of *now*. We cannot solve current problems by sitting in an office and cogitating on whether learning is a social process or an individually isolated activity. Someone must be aware of our partial knowledge about many things and, when confronted with a new technological development that purportedly can solve the major problems of education, must look with skepticism, analyze with precision, and refer to criteria that are as nearly unchallengeable as the human mind can construct.

The superintendent ultimately has responsibility for the decision accountability of all staff members in order to assure effectiveness in instructional processes and materials. The superintendent must determine the kinds of questions that must be answered before decisions are made. Chapter 5 presents an extended discussion of the kinds of questions that should be asked of manufacturers and vendors. These give the superintendent and his staff some clues to what they must demand in field test data for particular products. At the present time, few school agents ask for field test data. Those who have requested it have discovered that little is available. Producers and vendors of technological devices indicate that research has not been attempted or, when available, often is only a structured judgment by people who have used the product. This constitutes something short of the adequate assurance that a superintendent needs with respect to the use of the device under the conditions prevailing in his school system. Many will say that a superintendent has little time to analyze technical reports about technological devices that have been applied to instructional tasks. This is true. It does not mean, however, that the vendors need not have such evidence available. The superintendent is skilled in assigning his staff to evaluate and interpret evidence. The superintendent is in the same position as a medical doctor

who can be challenged with respect to the propriety of his treatment. The doctor does not depend on the vendor's word alone. He looks for research evidence and studies it carefully before he subjects his patient to new drugs. The educator must not depend on the sales pitch of advertising brochures, as attractive and convincing as they may be. The serious implications of his decisions dictate that judgment be made on something more substantial—namely, research evidence honestly, accurately, and completely reported.

Skeptical people now are concerned over strong efforts to get "commonized" knowledge and thinking about some of the current technological developments. One must scrutinize the schools' responsibility as it relates to efforts that tend to isolate one pupil from others. Total individualization may encourage anarchy insofar as group efforts are concerned. The threat is perhaps more to individual mental health than to political institutions. At present, individualization has become associated closely with the most enthusiastic supporters of the various technological items available to the instructional program. The realist will recognize that good teachers always have sought to understand the individual pupil and to gauge instruction to his unique abilities and needs. Those with a genuine concern for the individualized aspects of educative processes have provided genuine guidelines for merchandisers. The latter, however, have tended to concern themselves with less essential items in the instructional picture, such as mode of instruction as determined by straight rows of seats as opposed to other seating configurations.

Technology requires analysis, or system analysis as it is technically known. Individualization can be accomplished effectively by means of technological hardware, software, and logical formulations. There is no doubt that any person growing up in this era will be subjected to many pressures toward conformity. However, education theoretically prizes individuality and choice in a world of expanding alternatives. It seems that, philosophically, the issue of individualization versus conformity could be resolved in either the old or new systems of individualized instruction. Philosophy aside, however, the practitioner must achieve mastery of the old or the new if processes and products are to be made acceptable.

The computer has been proclaimed one of the front runners in efforts to further individualization. Computer-assisted instruction (CAI) provides opportunities for students to exercise selectivity in their learning efforts.

When there is a choice of computer or no computer, the superintendent and his staff must use the right reasons for making the choice. Assuming that CAI may be as efficient as conventional instruction and, in some instances, more efficient,

the next question is whether it is used for the right activities. There is little doubt that CAI provides an opportunity for pacing the learning process. (The question of pacing is independent of the selection and sequencing in software of the learning experiences themselves.) The computer, for those instructors who can use it wisely, can free them for other types of teaching tasks, leaving some of the routine work to the computer. Issues of this type were discussed at length in Chapter 1 and need not be pursued further here.

A persisting problem is the schools' obligation to develop proper software to take maximum advantage of technological devices. For the past decade manufacturers and vendors have accused educators of being incapable of or negligent in developing proper software. In turn, educators have pointed an accusing finger at manufacturers, vendors, and technologists for imposing technological devices inappropriate for education. Perhaps soon this sort of bickering can end.

The realistic administrator must assess the man-hour costs involved in programing materials for the computer when one hour of teaching entails 100 to 500 hours of preparation. This means that in addition to the high costs of electronic equipment, school systems must absorb tremendous staffing costs for developing materials for such machines. This would bankrupt most school systems under the present approach to financing. Much of the preliminary work has been funded by foundations and by federal dollars. Such responsibilities may fall more heavily on local communities in the future. (See Chapter 3 for more detailed treatment of anticipated and unanticipated costs.)

One of the major problems of the administrator at the present time is that of discriminating between the research stage of a technological device and the point where it has become sufficiently perfected for broad diffusion. In the meantime, the superintendent must rely on staff appraisals of research in order to determine good practice and possibilities of wise usage and reasonable economy.

Each local school system must determine the extent to which instruction shall be turned over to electronic devices sometimes controlled from distant points, as opposed to keeping the instruction in the hands of the teacher who too often is heavily overloaded. Any thoughtful person must recognize that the impact of technology on the instructional program has tended to force individuals to analyze what heretofore seemed unchallengeable. Analysis is the instrument of challenge, and, at the present time, the use of technology in the teaching and learning program must be analyzed in terms of instruction as a total system.

The instructional system is an array of interrelated factors in

the teaching-learning situation. These include the learner, the instructor, specialized personnel, a system of pedagogy, and supporting facilities and material, as well as a certain environment that has great impact on teaching and learning. A major change in any one of the many factors that make up the instructional system may cause major changes in one or many of its other aspects. It is impossible to tamper in any fundamental way with one part of the structure without having to give attention to all the others. The introduction of technology in the instructional program has a major impact on certain and ultimately all factors in the program. To deal with this impact, school systems need, particularly at the central office level, specially trained personnel. Superintendents must have close at hand special assistance of a kind never before needed if they are to cope successfully with the increasing pressures being exerted on their offices. Without this assistance the superintendent must either abdicate a considerable proportion of his responsibility for the instructional program in order to follow the pressures of the board and the public or must force his subordinates at the intermediate administrative and supervisory levels into situations for which they are not prepared. The foregoing suggests that the first step in applying technological assistance to the instructional program should be the securing of substantial specialized assistance for the superintendent.

Another of the current problems is that people want to retain the old principles, the old pedagogy, the old knowledge about learning, the old methods of teaching while at the same time beginning to use new equipment that requires new theories and models. The general philosophy of education and the particularized concepts of teacher-pupil interaction may need to be modified if technological devices and procedures are to be used rewardingly in the instructional program.

The purpose of this chapter, as suggested earlier, is to clarify the superintendent's responsibilities and the strategies by which he should develop the specialized assistance demanded by the emerging technology of the classrooms. The first requisite for evidence-based judgment is careful analysis. The concluding section of this chapter offers a suggested approach to analysis. It is hoped that such an analysis will facilitate wise decisions in planning all instructional improvement, whether or not technology as it is currently understood is involved.

Analysis and Planning

The unique administrative contribution might be designated as *analysis* and *planning*. Beyond the fulfillment of these two functions, there are major responsibilities for stimulating,

directing, and evaluating the instructional program. The focus of this presentation, however, is primarily on the planning of the instructional attack. In considering the application of current technology to instructional programs, the acquisition and analysis of relevant data is a primary undertaking. The initial task of analysis must precede planning for the instructional program.

An orientation to the analyzing-planning type of thinking about technology and the instructional program is offered in the form of the following chart and figures. Chart I is a list of random learning experiences from a nationally recognized curricular guideline which has been in use in the Madison, Wisconsin, Public Schools. The guideline provides for a K-12 program in human relations and intergroup understanding. Eight learning experiences are presented in Chart I. These have been selected from hundreds of such experiences provided in the document by random choice from the indicated subject areas. The figures are designed to aid administrators in determining what kinds of people and facilities are required to implement the learning experiences of Chart I in all classrooms of the school system.

Figure IV is an analytic model for planning the instructional attack. On the horizontal axis it identifies the learning supports that are available: teacher, library, laboratory, computer-assisted instruction, audiovisual aids, and games or simulation. Obviously, many more learning supports could be added on this axis, but for the convenience of illustration, they have been limited to these six. Listed on the vertical axis are items in the taxonomy of educational objectives for the cognitive domain, as presented by Bloom and his associates. This taxonomy includes knowledge, comprehension, application, analysis, synthesis, and evaluation. These "skills" are arranged in order of ascending achievement.

Chart I

Sample Intermediate Grade Learning Experiences in Human Relations-Intergroup Understanding [2]

A. Point out similarities and differences of people as members of groups and as individuals within these groups (social studies)

B. Become acquainted with the world's health heroes (health)

C. Arrange for unlike groups to work or play together (recreation)

D. Examine blood types under a microscope (use samples from different races and compare blood types) (science)

E. Develop bulletin board displays based on human needs and feelings which pupils find common to all people (art)

F. Compare decreased travel time between cities of the world (geography and arithmetic)

G. Demonstrate ways one may express himself through music (in many lands) (music)

H. Write a story in the first person about a child's day in school in another part of the world (creative writing)

The cell legend in Figure IV identifies *primary contribution* (P) to learning, *support contribution* (S), and *approximately equal contribution* (E) to learning. The data in Figure I are not intended as research "facts" but rather as rational "guesses." Each school district must determine how best to allocate its learning support resources for maximum effectiveness in achieving its objective. It will be noted that in Figure IV cell 1.1 indicates that the teacher has *primary* responsibility for the knowledge level of the experience identified in Chart I as Learning Experience A. The library is indicated as *support* for this learning experience, and CAI and games or simulation are shown as equal contributors, both of which in this case would be supportive in nature.

The matrix analysis which Figure IV represents provides a structure for the administrative staff to use in asking specialists to provide information of value in determining the instructional facilities necessary for this learning experience. Obviously, a superintendent will not subject hundreds of items like this to extensive analysis. He can, however, by using a sampling of learning experience items better make decisions regarding the addition or reassignment of personnel or budgetary provisions for facilities. Figure IV deals with only the first four learning experiences (A-D) in Chart I. This was done in the interests of space.

Many educators hold that the cognitive domain has been overemphasized at the expense of the affective domain. The same kind of analysis that was suggested above for the cognitive domain may be applied to the affective domain. Figure V analyzes the relationships between facilities and objectives in the affective domain learning experiences (Chart I). In Figure V the same learning supports are suggested on the horizontal axis as appeared in Figure IV, but the various objectives in the vertical column are of the affective domain, as listed by Krathwohl and his associates.[4] Once again, only the first four

Figure IV

Analytic Model: Planning Instructional Attack

School-Controlled Teaching-Learning

Taxonomy of Objectives [3] (Cognitive)	Learning Support Through:					
	.1 Teacher	.2 Library	.3 Laboratory	.4 CAI	.5 AV Aids	.6 Games Simulation
1. Knowledge	1.1 P-A,C S-D	1.2 P-B S-A	1.3 P-D S-C	1.4 E-A S-B	1.5 P-A	1.6 E-A
2. Compre-hension	2.1 E-B	2.2 P-B	2.3	2.4	2.5 E-B	2.6
3. Application	3.1	3.2	3.3 P-C,D	3.4 P-A	3.5 E-D	3.6 P-B
4. Analysis	4.1 P-A	4.2 S-B	4.3	4.4 E-D S-A	4.5 E-D	4.6
5. Synthesis	5.1 P-B,D	5.2	5.3	5.4	5.5 P-A	5.6
6. Evaluation	6.1 P-A E-B S-C	6.2 E-B	6.3 P-D	6.4	6.5	6.6

The descriptive terms on either axis will vary according to the problem, the group, and the purpose.

Illustrative Application: Chart 1, p. 86

Cell Legend: P—Primary contribution
S—Supportive contribution
E—Approximately equal contribution

Figure V

Analytic Model: Planning Instructional Attack

School-Controlled Teaching-Learning

Taxonomy of Objectives (Affective)	Learning Support Through:					
	.1 Teacher	.2 Library	.3 Laboratory	.4 CAI	.5 AV Aids	.6 Games Simulation
1. Receiving (Attending)	1.1 P-A,C	1.2 P-B	1.3	1.4 S-B S-A	1.5 S-B S-A	1.6
2. Responding	2.1 E-C,D S-A	2.2	2.3 P-C,D	2.4 P-A	2.5 E-D	2.6 E-D S-A
3. Valuing	3.1 P-B E-A,C	3.2 E-A	3.3 P-D E-C	3.4	3.5	3.6
4. Organization	4.1 E-B,C,D S-A	4.2 E-D	4.3 E-C,D	4.4 E-B	4.5	4.6 P-A
5. Value Complex	5.1 P-A E-C,D	5.2	5.3 E-D	5.4 P-B	5.5 S-A	5.6 E-C S-A

The descriptive terms on either axis will vary according to the problem, the group, and the purpose.

Illustrative Application: Chart 1, p. 86

Cell Legend: P—Primary contribution
S—Supportive contribution
E—Approximately equal contribution

items from Chart I are analyzed in terms of primary, supportive, or equal contributions of support from the various persons or facilities in the school system. Here again, it should be observed that the teacher plays a prominent role in the affective as in the cognitive domain. The superintendent must raise the issue and must request specific data from his staff to arrive at the proper balance of other supports in addition to the teacher.

The superintendent can meet his unique administrative responsibilities in budgeting and other support provisions if such analyses are based on appropriate data. He might at the same time use this kind of thinking to reassure teachers who often think they may be displaced by a technological facility. Teachers can be brought to realize that technology can be used primarily to make their own effort more effective. The analytic system is offered, then, as a way of thinking for administrators who must initiate and structure analyses and who must exercise controls over the facilities that are made available to accomplish the educational objectives of the school.

A basic idea in the minds of the vast majority of people is that the most important item in the learning environment is the teacher. Equally basic to our established concept of teaching is the view that the pupil is the target for the teaching effort. Practically, one must recognize that teachers would not be hired or engaged in teaching were it not for the purpose of influencing the basic learning opportunities of pupils. Pupils, on the other hand, could learn without any teaching effort in the form of either a person or a device. History is replete with examples of self-taught people. The culture of today, however, seems unwilling to hazard the potential waste associated with self-teaching. It is generally accepted that instruction or teaching is an essential part of the responsibility that society has for its youth.

Teaching, regardless of the medium, is basically the selection, organization, presentation, and evaluation of learning experiences. These learning experiences, whether specified or not, mean those experienced by the object of the teaching effort—the pupils. The range in the selection of items as learning experiences is generally broad and sometimes startling. The selection may range from the decision to use a particular text to protesting violence on television.

The evaluation of learning experiences, which primarily is an evaluation of teachers' effects on pupils, involves a wide range of tasks. This range extends from rewards for natural or inherited talents of the individual to the technically measured behavioral outcomes identified in taxonomic analyses. Evaluation of learning experiences remains a complex task. Even though complex, however, it persists as an essential function of analysis and planning.

Footnotes

1. Bloom, Benjamin S., editor. *Taxonomy of Educational Objectives.* Handbook I: Cognitive Domain. New York: Longmans, Green and Co., 1956.
2. Madison Public Schools. "Suggested Learning Experiences." *Education for Human Relations-Intergroup Understanding.* Madison, Wis.: Department of Curriculum Development, the Public Schools, 1964.
3. Bloom, Benjamin S., *op. cit.*
4. Krathwohl, David R., editor, and others. *Taxonomy of Educational Objectives.* Handbook II: Affective Domain. New York: David McKay Co., 1956.
5. *Ibid.*

Other References

1. Council for Basic Education. "The Electronic Revolution in the Classroom." Discussion at public meeting at Washington, D.C., October 27, 1967. *Occasional Papers Number Fourteen.* Washington, D.C.: the Council, 1967. p. 9.
2. Division of Audiovisual Instructional Service. *Recommendations for Reporting the Effectiveness of Programed Instruction Materials.* Washington, D.C.: National Education Association, 1966.
3. Gage, N. L., editor. *Handbook of Research on Teaching.* Chicago: Rand McNally, 1963.
4. Homme, Lloyd, and others. "What Behavioral Engineering Is." *Psychological Record* 18: 425-34; July 1968.
5. Knezevich, Stephen J. *Administration of Public Education.* Second edition: New York: Harper & Row, 1969. Part V.
6. *Educational Product Report.* Periodical. All issues. Educational Products (Information Exchange Institute, 386 Park Avenue South, New York, N.Y. 10016).
7. *Educational Technology.* Periodical. All issues. (Educational Technology Publications, 456 Sylvan Ave., Englewood Cliffs, N.J. 07632.)
8. Pearce, Lucia. "Environmental Structure: A Third Partner in Education." *Educational Technology,* September 15, 1968. pp. 11-14.

5. The Administrator and Instructional Technology: What Questions Should Be Asked?

Few Latin maxims are as widely known (albeit unheeded) as *caveat emptor*. Nowhere is this admonition more compelling than when considering the purchase of new educational hardware. The purpose of this chapter is to help the school administrator with the "emptoring."

The school administrator today finds himself swamped by blandishments of the new technology borne by advertisements, exhibits, and salesmen. Understatement is not their salient feature. In many cases the beleaguered administrator must consider the purchase of equipment and supplies that did not exist in his own teaching days. Confusing claims make the choice even more difficult. When an associate commissioner of the U.S. Office of Education predicts that computer-assisted instruction can take over teaching in a few years, our school administrator is spurred to catch up, lest his school system become an object lesson in obsolescence. When a professor of education assures him that the so-called instructional revolution is indeed not a revolution at all or is, at most, a revolution many years in the future, he is given pause. A foundation hailed the Midwest Project on Airborne Television Instruction as a prototype "that may make educational and electronic history" and then dropped it quietly a few years later in what was probably the most expensive single failure in the history of educational technology. A superintendent might well be relieved that he was not grounded by overinvestment in that abortive flight. As George Herbert warned: The buyer needs a hundred eyes, the seller not one.

The conceptualization of the allegedly impending "total educational revolution" may overwhelm the superintendent. Neither

his formal preparation nor his experience has prepared him for such forbidding phrases as "massive and radical design of the curriculum," "end of the myth of local control of the curriculum," "drastic changes in the role of the teacher and the administrator," "integrative systematization of the entire learning complex," and "integrative thinking in exploring the realities of the organic curriculum." Unlike the housewife, the superintendent has no "seal of approval" or special consumer ratings to help him weigh these strident and confusing claims. About the only information relevant to his task lies in the glib pronouncements of "educational breakthrough" by free-lance writers for the slick magazines or the sometimes incomprehensible reports of esoteric research studies in sophisticated professional journals, which caution repeatedly against transferring conclusions to situations other than those with variables identical to the ones prevailing in the original study. More often than not the conclusion of these studies is "no significant difference."

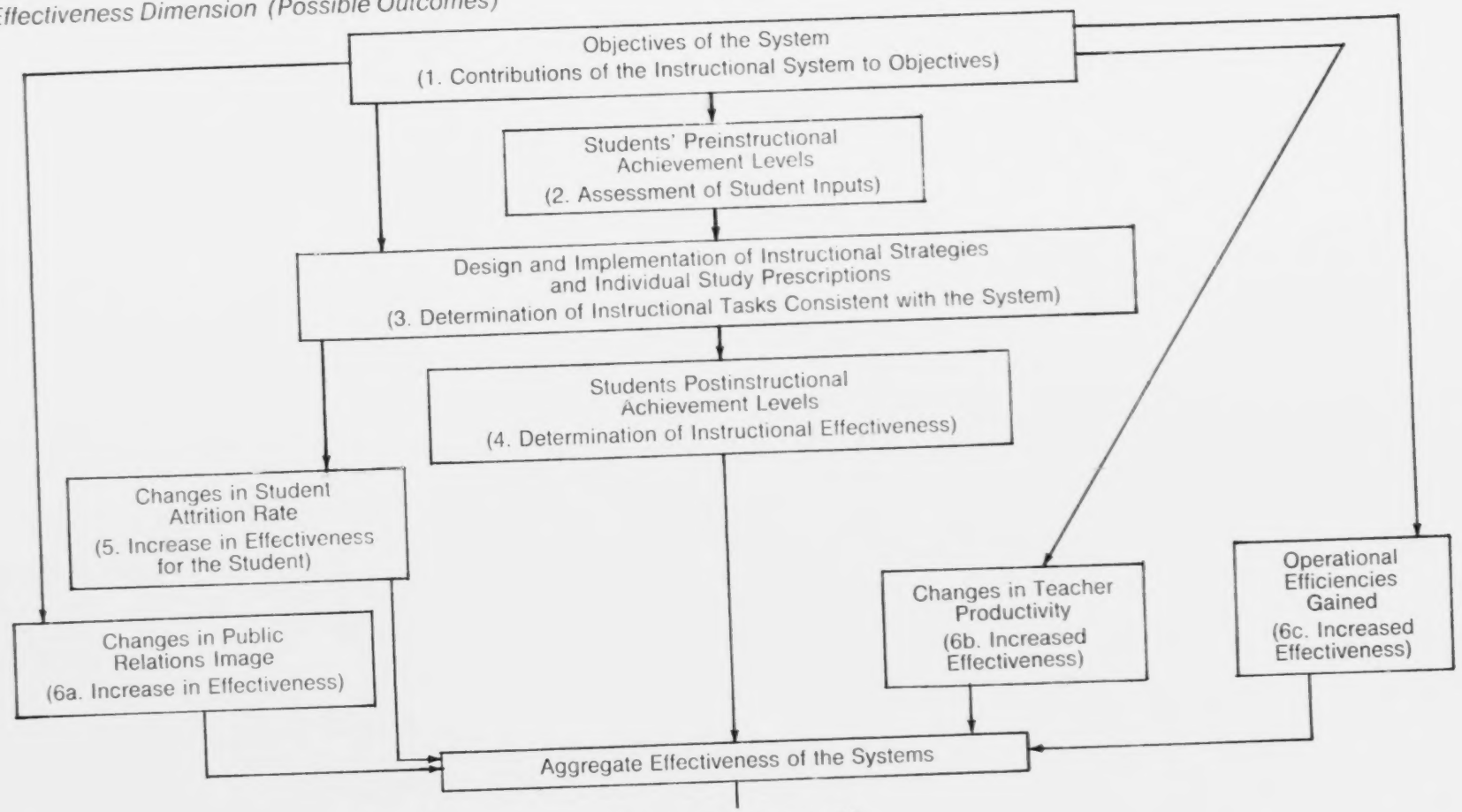
Even if there were clear answers to the quality and capability of the products that confront the superintendent, many other questions would remain. Is the new instructional system better than the one it would replace? Better for what purposes? Are these purposes compatible with our educational objectives and aspirations? Is the system effective with all students or only some students? Is it multipurpose? Can it be helpful to teachers, counselors, and administrators too? Will the professional staff need retraining to use it effectively? If so, how much retraining will be necessary and how much will it cost? How much does the technology cost? What will it cost to operate, repair, and maintain? Is it technically and educationally compatible with other instructional subsystems with which we must live? Will students and parents like it? What psychological effects will it have on students and teachers? Will it introduce unanticipated issues at the next round of bargaining with teachers? Will it require additional space or modifications in our plant? Will specialized personnel be required to operate it? If so, are they available? Will it become obsolete soon? Will greater mass production lower the cost soon? Who should decide these things? Where can one get expert advice?

A Cost-Effectiveness Evaluation Systems Model

This formidable array of questions may prompt the superintendent's early retirement unless he has rational means of putting these important questions into logical sequence, seeing their dynamic interrelationships, and gathering the necessary data for answering them. These processes are the fundamental components of systems analysis discussed earlier. Systems analysis itself may be regarded as the essence of educational

Figure VI *Cost/Effectiveness Evaluation Systems Model*

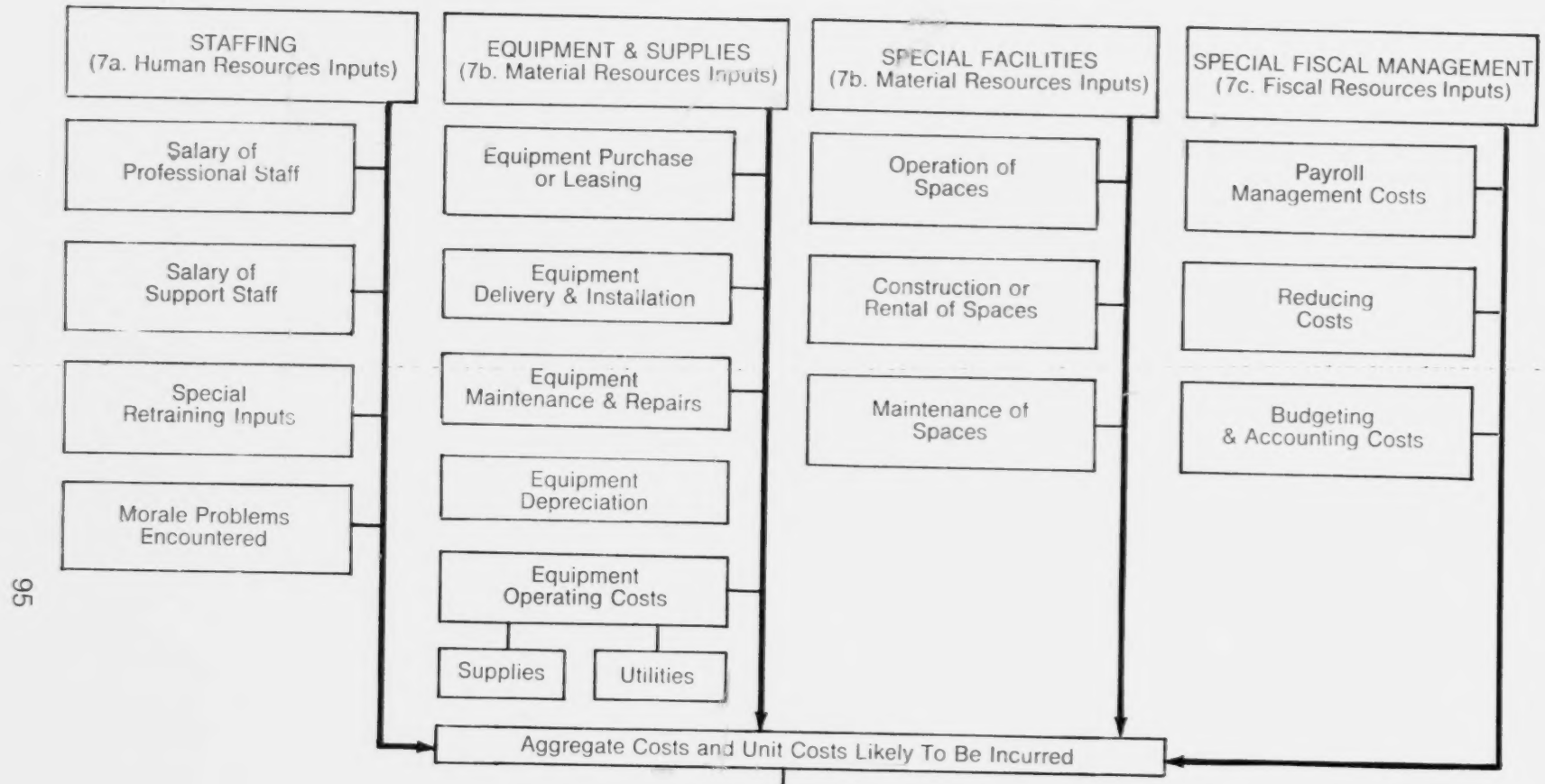
Effectiveness Dimension (Possible Outcomes)


Objectives of the System
(1. Contributions of the Instructional System to Objectives)
Students' Preinstructional Achievement Levels
(2. Assessment of Student Inputs)
Design and Implementation of Instructional Strategies and Individual Study Prescriptions
(3. Determination of Instructional Tasks Consistent with the System)
Students Postinstructional Achievement Levels
(4. Determination of Instructional Effectiveness)
Changes in Student Attrition Rate
(5. Increase in Effectiveness for the Student)
Changes in Public Relations Image
(6a. Increase in Effectiveness)
Changes in Teacher Productivity
(6b. Increased Effectiveness)
Operational Efficiencies Gained
(6c. Increased Effectiveness)
Aggregate Effectiveness of the Systems

continued on page 96

Cost Dimension (Probable Inputs)

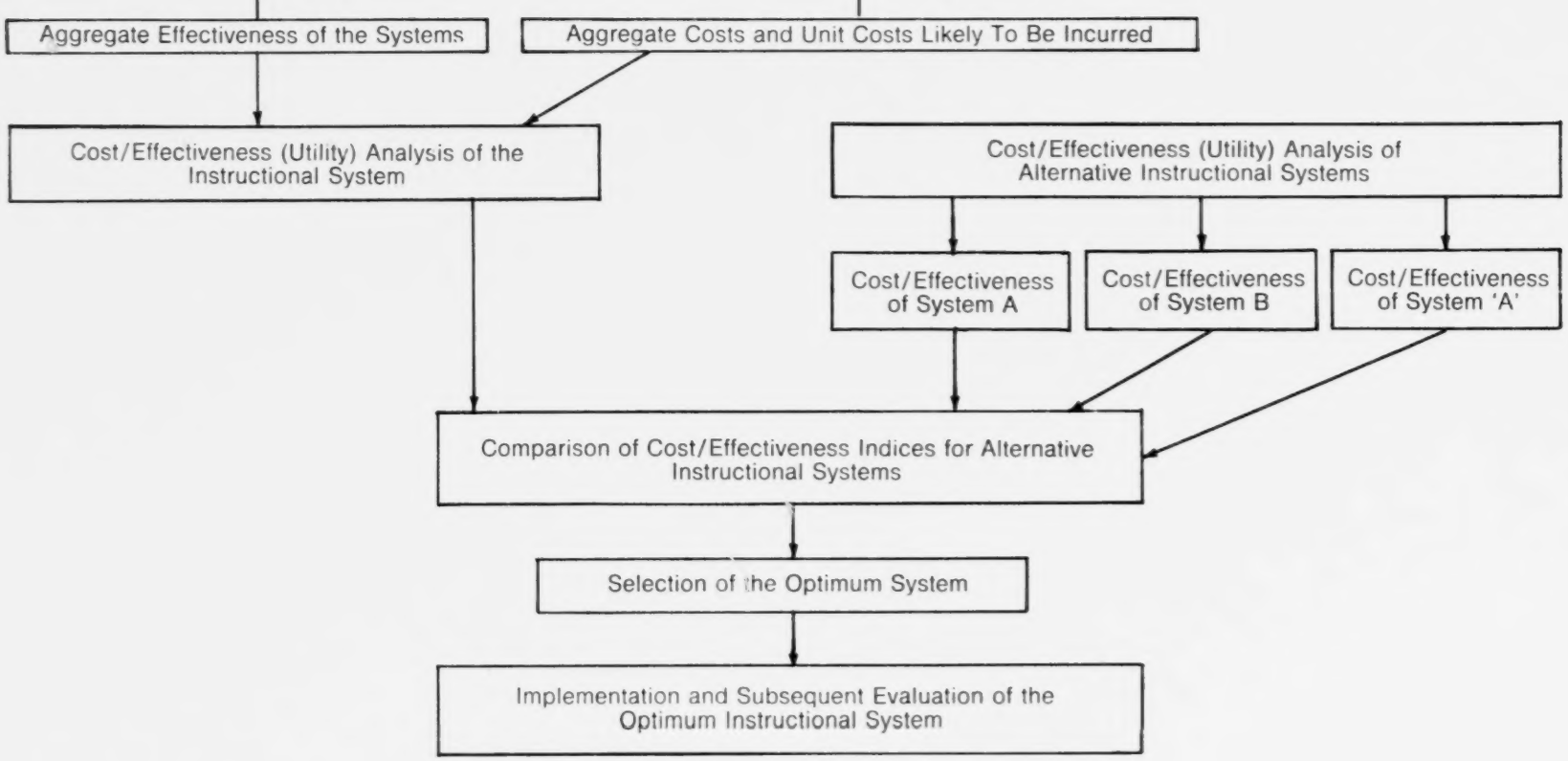
Administrative Planning Cost



continued on page 96

continued from page 94

continued from page 95


Aggregate Effectiveness of the Systems
Aggregate Costs and Unit Costs Likely To Be Incurred
Cost/Effectiveness (Utility) Analysis of the Instructional System
Cost/Effectiveness (Utility) Analysis of Alternative Instructional Systems
Cost/Effectiveness of System A
Cost/Effectiveness of System B
Cost/Effectiveness of System 'A'
Comparison of Cost/Effectiveness Indices for Alternative Instructional Systems
Selection of the Optimum System
Implementation and Subsequent Evaluation of the Optimum Instructional System

technology. It may help in the process of selecting instructional environments which are highly responsive to specified objectives and which yield feedback, evaluation, and correction. Part of this process requires precise definition of objectives and operations and systematizes the instructional endeavor into predictable relationships. It specifies a product, a sequence of operations, and a check on achievement.

The essentiality of these rational processes has long been recognized by educators, but their feasibility has been questioned because of the difficulties of speaking precisely about such a highly socialized enterprise as education. However, this means-ends approach is not unfamiliar to educators who have been accustomed to thinking of lesson planning as a sequence of objectives, activities, and evaluation in terms of objectives. The difficulty is that educators are left to their own devices in accomplishing these tasks—devices that are usually neither rigorous nor controlled. Systems analysis uses the same means-ends concept but requires more rigorous thought at each point of decision and permits alteration at any essential point in the process as any change in the variables intrudes on the process. The systems approach also yields improved cost-benefit comparisons.

The accompanying diagram (Figure VI) presents an illustration of a cost-effectiveness evaluation systems model. It is not regarded as a prototype in that other models could be devised. It is not an infallible guide to right decisions.

First, it is incomplete; not all variables can be foreseen. Second, it is oversimplified and focuses on instructional systems; not all relationships among variables can be diagramed. Third, it calls for data that are imperfect in some cases. Fourth, it provides little assistance in making value judgments. Nonetheless, the model calls attention to the more essential considerations in selecting instructional systems and places them in a pattern that reveals their interaction.

The sequence of processes includes the following: (1) definition of the purpose of the instructional system (or of a particular product within the system); (2) assessment of student inputs; (3) definition of instructional tasks and strategies; (4) determination of instructional effectiveness; (5) determination of additional effectiveness of learning for the student; (6) determination of other gains in effectiveness; (7) determination of aggregate gains in effectiveness; (8) determination of various staffing, equipment, facilities, and related inputs; (9) calculation of current cost category of inputs; (10) calculation of capital cost category of input; (11) calculation of costs per student hour; (12) evaluation of cost for the new instructional system effectiveness; (13) comparison with cost-effectiveness indices of alternative systems; (14) selection of system and selec-

tion of preferred product within the system; and (15) shakedown, refinement, and evaluation in experimental use. Note that the model can be used for the selection of an instructional system (conventional instruction in language versus instruction via language laboratory) as well as for the selection of a particular product within a selected instructional system (Company X Language Laboratory versus Company B Language Laboratory). Not all components of the model would necessarily apply in both cases. Usually the two problems will be analyzed concurrently because data required for the latter are also essential to the former.

Let us turn our attention now to a consideration of these processes.

1. *Definition of the purposes of the instructional system.* The first essential task is the definition of the purposes or educational objectives of the educational system. This must not be an abstract exercise in rhetoric but a working document that specifies with precision the behavior which the student hopefully will acquire. The analytic models described in Chapter 4 illustrate ways of analyzing educational objectives systematically in terms of specific student behaviors sought. The evaluation systems model here builds on the product of the analytic models described in Chapter 4.

2. *Assessment of student inputs.* The second step requires an assessment of the student inputs into the system in terms of the achievement and needs of each student. This assessment provides a benchmark for the later assessment of the increment in student achievement resulting from alternative systems of instruction under consideration.

3. *Definition of the instructional tasks and strategies.* This process (see again the analytical model in Chapter 4) yields specifications of the curriculum, the course of study, or the learning unit. It specifies what is to be taught (and hopefully learned). In conventional instruction, this is stated in the aggregate for all students. Ideally, individualized instructional prescriptions should be delineated for each student. However, without automatic data processing equipment, it is virtually impossible to prescribe instruction uniquely adapted to the level of achievement of each student. The computer permits high-speed retrieval and analysis of data on each student and, when properly programed, prints out appropriate instructional prescriptions.

4. *Determination of instructional effectiveness.* Gains in instructional effectiveness are computed by subtracting students' preinstructional achievement from their postinstructional achievement, using measures relevant to the prescribed educational objectives. Measures of cognitive development are usually readily available, but measures of affective growth are

less well developed. The problems of measuring achievement, particularly in the affective domain, are legion. These problems are discussed in Chapter 4. A precise cause-and-effect relationship between an increment in achievement and a new instructional system is difficult to establish without complex systems of processing and analyzing data about individual students—systems that very few school systems can currently provide, but the difficulty and complexity of the task does not justify its neglect. However difficult, the school system is obliged to make the best determination possible of the effectiveness gains accruing to the student against the criteria derived from the original statement of educational objectives.

5. *Determination of additional gains in effectiveness in learning by the student.* The crucial importance of gain or loss in student holding power must not be overlooked. The dollar cost cannot, of course, be computed. Two examples will illustrate how it may be considered. Suppose that one instructional system yields a lower per-student cost, but at the expense of a higher rate of student failures and dropouts. In this instance the high cost of the "scrap" must not be ignored. An instructional system or subsystem may also promise greater reclamation or retention of potential dropouts. The talking typewriter, for example, is said to be especially effective in reducing the withdrawal of autistic students who may react easily to the impersonality of the machine while refusing to interact with people. If this is so, the perhaps $1,000 per month rental for the machine may be justified for autistic students, although the same machine might be considered too expensive for more typical students.

6. *Determination of other measures of effectiveness.* In considering effectiveness chances, one must be reminded that persons other than students are involved in the educative process. System A, which might be superior to System B in both cost per student and effectiveness measures, might extract a high cost in teacher morale and commitment, particularly if it enslaves teachers to humdrum tasks. The consequence might be eventually to reduce the effectiveness measures because of reduced teacher commitment, enthusiasm, and efficiency. On the other hand, some modes of instructional technology may very well increase the teacher's productivity, just as industrial technology has expanded the worker's productivity. Higher morale, with its concomitant benefits such as reduced turnover and absenteeism, might yield other, more obscure benefits.

There may also be public relations benefits and costs. Would a slight increase in learning effectiveness per pupil be worth the hostility of parents who dislike a particular instructional system?

Effectiveness may be measured also in the acquisition of equipment that can be used for purposes other than instruction

or for instruction in other subjects or other grade levels, thus increasing its usefulness. For example, a dial-access system acquired primarily for the instruction of students might also prove valuable in the inservice development of teachers.

These possibilities are cited for illustration of ancillary benefits or loss of benefit and are by no means exhaustive.

7. *Determination of aggregate effectiveness.* After all specific measures of effectiveness have been estimated and weighed, a composite "effectiveness score" can be determined for each system or subsystem.

8. *Determination of various staffing, equipment, facilities, and related inputs.* At this point the focus shifts to the second sector of the model, namely, inputs or costs demanded for system operation. This includes the identification of the relevant resources that must be utilized for the system. The human resources required to implement an instructional system demand professional staff; support personnel such as aides, technicians, and supervisory personnel; and special training staff. The material resource input consists of equipment, supplies, facilities, and fiscal resource management capability.

9. *Current expenditures.* After the resources are identified, it is necessary to account for each on the basis of capital and current expenditures. The type of expenditure required to gain each set of resources mentioned above must be known to ensure an objective basis for unit and aggregate cost analysis of inputs.

The use of mass media of instruction, computer-assisted instruction, independent study, and other modes of instruction may alter class size substantially, although there is little evidence to suggest that they have so far changed professional staff-student ratios materially in the aggregate. Although the evidence is less reliable than one would wish, it suggests that the new instructional systems tend to require more, rather than fewer, professional staff per 1,000 students. More specific examination is necessary in considering instructional subsystems. Large-scale application of self-sustained individual study could conceivably require fewer professional staff per 1,000 students. Conversely, extensive use of individually prescribed instruction without computer assistance would increase the number of professional staff needed. Use of any instructional system involving sophisticated hardware will require the assistance of additional specialized personnel—programmers, cameramen, projectionists, repairmen, machine operators, and perhaps engineers. These necessary specialists should be carefully inventoried and estimates of the total number required carefully projected. In some cases, the needed specialists may not be available in sufficient numbers. If not, it must be decided whether personnel presently employed can be trained in rea-

sonable time and expense to undertake the new responsibilities.

The time required for students to learn a given body of material will affect current expenditures. If, for example, a programed unit of instruction permits the average student to master the lesson in 20 percent less time, a commensurate saving can be anticipated in current expenditure—unless the time saved is utilized for additional learning rather than for acceleration of the student's progress through school. If additional learning is accomplished through the more efficient mode, then the advantage is manifested as a benefit in Step 7 rather than as a monetary saving in cost.

Consider now the current expenditures for the materials essential to the instructional system. Cost of equipment, except for its depreciation, is considered later as capital expense, as are nonconsumable supplies. In estimating current expenditures, consideration must be given to the costs of operation, repair, maintenance, depreciation, administrative control and overhead, and necessary expendable software. Many school systems have learned to their sorrow that expenses of operation, maintenance, and repair can run very high. One school system reported that it spent as much in three years for operation, maintenance, and repair of its dial-access system as it spent for its purchase. (One is reminded of the major university that happily accepted the gift of an enormous estate from an affluent alumnus only to discover that it could not afford to maintain it.) Federal monies help many school systems buy the hardware, but such money may not be available to repair and maintain it.

Many factors impinge on cost of maintenance and repair: frequency of breakdown, availability of parts and service, vulnerability to vandalism, and many others. It is prudent to require in the terms of sale a parts and labor guarantee for a year following date of acceptance (not date of installation) of the system. This will at least assure a good shakedown of the system. In the long run, there are probably no better indicators of the reliability of maintenance and repair than the experience and reputation of the manufacturer and the volume of business that the district does with the vendor. The cost of maintenance and repair is difficult to estimate in a technological age that can return astronauts surely from outer space but cannot produce automatic vending machines that deliver the goods or return the coins. The cost of vandalism may be escalated severely with the addition of expensive equipment in the schools. Whether recalcitrant students in a self-instructional system will attack their dial-access consoles rather than their teachers to relieve their frustrations and hostilities is not yet known. In any case, the fragility of the hardware will be an increasingly important criterion in selecting systems.

Any gain or loss in costs of administration and overhead must also be considered.

Computer-assisted instructional systems may require the rental rather than the purchase of expensive equipment. Rentals should, of course, be considered as current expenditure. Rental costs for computer-assisted instructional programs vary greatly and may be difficult to determine. If a computer is purchased, it must be used sufficiently to reduce the high cost of unused time. In larger districts purchase may be feasible, particularly if the computer can be put to administrative as well as instructional tasks. In some cases, the computer may be purchased jointly by several cooperating school systems. If rented, the school system may utilize the computer on a time-shared basis with other customers. An incalculable cost of this arrangement is the cost in time lost between query from a remote-access station and the response by the computer when other time sharers with higher priorities overload the computer's capacity.

Depreciation is an important but easily overlooked current expenditure. Depreciation is a function of rate of obsolescence of the hardware and its supporting materials. Education, for all its faults, does not worship the god of built-in obsolescence. In an earlier section of this report, reference was made to the fate of brilliant gadgets of yesteryear. The dilemma lies between procrastinating endlessly until ultimate cost-benefit perfection is determined at infinity and overinvesting prematurely in unproven gadgetry that must soon be discarded or replaced.

There was no way to have foreseen six years ago that mechanical teaching machines would be all but abandoned and educational television diffused slowly, while during the same period language laboratories would enjoy rather spectacular successes for awhile and then wane. There was little in the educational literature which could have enabled one to make accurate predictions any more surely than tip sheets lead one to certain fortune on the stock market. Perhaps the best defense against obsolescence is to follow the vanguard of other school systems, a luxury which the vanguard cannot enjoy.

Consideration must be given to the costs of expendable or consumable software required by the system. Some instructional media, such as the textbook, are self-contained with their own software. "Hardware" media, such as the learning laboratory, may be purchased but not used without supporting software. Indeed there are machines available for which no instructional content has been prepared. Many mistakes have been made in purchasing expensive hardware for which high quality software is unavailable. A machine whose software is entirely consumable will be more expensive than one that requires fewer consumable supplies. With some media it is possible to develop inexpensive homemade software; in other instances

only software produced by a particular manufacturer is acceptable to the machine. (Razor blade companies may not be the only enterprise that finds greater profit in the consumable supplies than in the original hardware.) A school system may discover that it is locked into software produced by a single manufacturer after it is committed to a given set of hardware.

This consequence has implications that relate to costs as well as to flexibility of the curriculum. One has come to expect that any tape recorder will handle all standard tapes. Unfortunately, such compatibility does not yet prevail in all other media of instruction. The prudent school system will investigate carefully the problems of compatibility, availability, and quality of software before investing substantial capital in hardware. Many school systems have learned this lesson the hard way. Both intrasystem and intersystem compatibility are important. Many schools will eventually want to "plug in" on local, regional, state, and national information services. Their ability to do so will depend on intersystem compatibility.

Exploring the relationship of school plant and facilities to new instructional systems and media is also essential. For example, one of the great impediments to the development of closed-circuit television has been the lack of physical facilities for large-group instruction in most traditional school buildings. Without these large-group facilities, TV cables, and adequate power sources, closed-circuit televised instruction becomes unbearably expensive. Any form of individualized instruction requires carrels or other types of individual study space—a facility that is commonly lacking in older buildings. The cost of providing these facilities in renovated buildings may be the variable that makes this mode of instruction unacceptable. Other less sophisticated instructional systems may require little modification of school plant. In some cases, space may be used more effectively at lower per-student costs. In calculating comparative costs of space, it is essential that distinctions be made between operating expenses and capital expenses.

10. *Capital expenditures.* In Chapter 3 the actual capital and operating costs of several educational technology media are considered at length. At this point, we simply relate questions of cost to the Cost-Effectiveness Evaluation Systems Model (Figure VI). These costs may derive from considerations of staff, equipment and materials, plant and facilities, and students. Each will be considered in order.

In many instances it will be necessary to retrain classroom teachers to handle the new instructional system effectively. This should be regarded as a capital expenditure because in most instances it will be a one-time cost (if one can assume that a new generation of teachers will receive this training as a part of their preservice preparation). In any event, this cost can be

overlooked only at the peril of the new system. Many new instructional systems have been relatively ineffective because the school's professional staff was unprepared to handle them effectively. Failure to provide this important input can only impair the efficiency of the system.

A major capital expenditure item is the instructional system or subsystem equipment. Price tags of the less sophisticated items available for purchase presumably present little difficulty. Difficulty arises, however, in estimating the costs of the more sophisticated hardware and the hardware that must be rented—particularly computer-assisted instructional systems. Much more field testing and more careful cost accounting are necessary before costs can be estimated reliably. Sometimes capital costs of purchase must be compared with current expenditure for rental of the equipment.

One can divide the sum of purchase price and the cost of installation, repair, and maintenance by the cost of annual rental to produce the minimum length of time in which the equipment must serve to yield a saving through purchase.

In some cases special gadgetry is required for linking the hardware to other components that may be necessary to code the input, decode or interpret the output, or perform other tasks essential to the effective use of the equipment. In such circumstances, bid specifications should be written to include costs of all ancillary equipment essential to the performance of all functions expected of the total installation. The costs of these ancillary components should be specified and "read into" the specifications. So should be the costs of installation. In some instances it may be necessary to examine a flow chart of the entire process from the origin of the input through the utilization of the output by the teacher or student to be sure that all essential components are considered. Better yet, a demonstration or simulation of the entire process may be necessary to ensure that all components are available, compatible, costed out, and working before adoption or acceptance. This demonstration will also help the purchaser realize the complexity of the installation and its operation. Wherever feasible, a demonstration of the use of the equipment in real or simulated situations may be necessary to prevent oversight of essential considerations.

A school system may have to consider the cost of adopting a new system of hardware in relation to its current stockpile of incompatible components. For example, 8mm motion picture projection has recently been refined to produce more acceptable technical quality. Yet many school systems have a substantial resource center of 16mm films, projectors, and cameras and therefore would find it uneconomical to make the change-over.

11. *Calculation of costs per student hour.* The next phase in evaluating the instructional system is calculating the cost per student hour of instruction. Capital costs are divided by the expected life of the equipment, materials, or space and added to the annual operating costs. This sum is divided by the number of students using the system. It is at this point that the importance of the divisor is evident. The installation of a computer, for example, might be a tremendously expensive capital investment for a school system of 4,000 students but an easily justifiable one in a school system of 40,000 students. To return to an earlier example, the purchase of a talking typewriter would be prohibitively expensive to serve one autistic student but not so when there are a sufficient number of needy students to keep the machine continuously in use throughout the school day.

The cost per student is converted then to cost per student hour by taking into account any savings or losses in student learning time for one instructional system as opposed to an alternative. This step entails an essential refinement in the evaluation of cost. At this point consideration must be given to whether the cost of the instructional system or subsystem under consideration would yield (a) a reduction in the cost of producing the same quality product or (b) an improved product at a cost not increased disproportionately to the increased benefit.

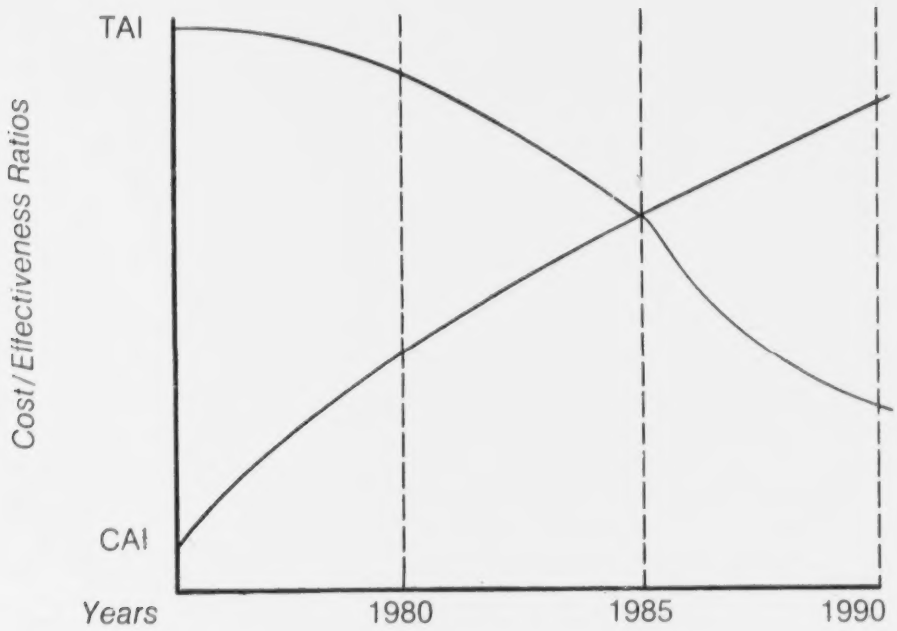
12. *Determination of cost-effectiveness.* At this point, the cost and the effectiveness of an instructional system are considered together. This type of analysis is known variously as cost-benefit analysis, cost-utility analysis, or cost-effectiveness analysis. They are not synonymous, although popular literature tends to make them so. Essentially, the measure of cost and the measure of effectiveness are joined in a cost-effectiveness ratio or index.

13. *Evaluation of cost-effectiveness of alternative systems.* At this point, the cost-effectiveness (c/e) indices of alternative systems are compared to determine the preferred system or subsystem.

It is essential that variations in cost and effectiveness through time be considered, lest future advantages of one system be sacrificed through preoccupation with present comparisons. For example, Figure VII helps us visualize the index score of computer-assisted instruction (CAI) and traditional instruction, represented here as teacher-assisted instruction (TAI). Figure VII is intended simply as an illustration and in no way an actual forecast. The horizontal dimension reveals time, and the vertical dimension reveals the size of the index ratio or computed comparison between costs and effectiveness. The higher the index score the better the alternative. It is estimated that the costs of CAI until 1985 will remain high in relation to its effectiveness as

Figure VII

Cost/Effectiveness Ratios for
CAI—*COMPUTER-ASSISTED INSTRUCTION and*
TAI—*TEACHER-ASSISTED INSTRUCTION OVER TIME*



an instructional system. It may be prohibitively expensive for all districts except those with grants available for experimental or developmental purposes.

Cost-Effectiveness Ratios

In the decade of the 1970's, the costs of TAI will escalate rapidly, without a concomitant increase in effectiveness, as teachers enjoy increased success at the bargaining table. Thus the cost-effectiveness (c/e) index will indicate decreased effectiveness. Simultaneously, the costs of CAI may decline as mass production of computers and software yields lower costs. Between 1985 and 1990 a number of school districts might be expected to begin the conversion from TAI to CAI because of the economic advantage of the latter instructional system.

This model is, of course, oversimplified since teacher-computer systems, rather than the pure alternatives suggested by the figure, will probably be in general use. The date of the crossover, 1985, may be too conservative or too optimistic, depending on one's vantage point.

Only as alternative instructional systems and subsystems are analyzed through the disciplined procedures suggested by the Cost-Effectiveness Evaluation Systems Model can rational de-

cisions be reached. The relevant questions must be raised. The interrelationship of many variables must be seen. The model permits one to do this, imperfect as the data may be.

As the product of education becomes increasingly crucial to our society and as school costs continue to escalate, the school administrator will find it increasingly difficult to escape from cost-effectiveness estimates simply because of the difficulty in producing reliable data relevant to intangible objectives of education. Consider, for example, this statement by New York City's Mayor Lindsay:

I am determined to analyze our educational expenditures and to insure that every dollar is spent with maximum effectiveness. It is now almost impossible to make a meaningful analysis of the educational budget in terms of specific goals, program elements, and program costs.

Clearly the mayor is invoking the concepts of systems analysis in his attack on cost-effectiveness of alternative approaches used in the New York City school system. However much one might resist the "cult of efficiency," its compelling presence is a persistent reality in an era of rapidly escalating school costs.

14. *Selection of instructional system or product.* After the cost-effectiveness of various instructional systems or subsystems has been analyzed, the preferred choice is presumably determinable. After the instructional system or subsystem is chosen, important questions still remain with respect to the choice of competing products within the same family of systems. One must now apply a new set of questions as well as reapply some of the questions already relative to the quality of competing products. Comparative costs of purchase, installation, operation, repair, and maintenance of one product against a similar product by another manufacturer are relevant. Questions of quality of output or effectiveness must also be raised.

15. *Shakedown, refinement, and evaluation after experimental use.* Systems theory requires a continuous cycle of the processes specified in the model; this is achieved by "closing the loop" between the last and the first. After the installation of the selected product, it is used experimentally. The processes specified in the model are reapplied to the system or product now in actual use—ideally in comparison with a control group.

Questions for Producers and Vendors

The producer's advertising and salesmanship should be considered with prudent skepticism. Salesmen and advertisers are not generally noted for making modest claims for their products. The exaggeration factor notwithstanding, certain useful information can, of course, be acquired from the producer's salesmen and advertisements. The tone of the advertising copy or the sales pitch often reveals inadvertently the credibility of

the statement. For example, one producer claims to have developed an inexpensive instructional gadget that is "95 percent as effective and as quick as computer-linked teaching systems costing 95 times the price." What a coincidence that both the effectiveness and the speed came out at almost exactly the same percentage of all competing products!

The sales pitch and the advertising copy can be analyzed with respect to several crucial questions. Are the purposes of the product stated clearly and precisely in terms of the targeted behavioral or other objectives? Are the authors of the software clearly identified as competent and responsible professionals? Through how many field-testing and revision cycles have the instructional materials passed? Where and under what conditions was the field testing done? Has this testing and research on the product been reported? Is it available for examination? Has the product been reported and is it available for examination? Has the product been accepted for use under any government contracts? Are technical specifications of the product available for in-detail examination? Are there any installations of the product in actual field situations which are available for observation? Is the vendor willing to include a service and parts guarantee and a performance bond for one year following acceptance? What other warranties are available? Is the vendor willing to bid or quote prices on all ancillary equipment essential to the total operation of the central components? Are reliable estimates of per-pupil hour costs available? Can the data supporting these estimates be examined? Can a list of other adoptions of the product be made available? Can power sources and other installation requirements be guaranteed reliable?

Certain relevant questions may be raised about the producer. How long has the producer been active in this field of production? Is he known for quality work? Although length of experience is not a sure guide to quality, few producers are likely to turn out acceptable products overnight. Just as we have come to expect certain textbook publishers to turn out consistently good work in certain fields, the reputations of instructional systems manufacturers might provide some guidance toward determining quality. How much research and development capability does the producer have? As noted earlier, the refinement of instructional systems is a slow, painstaking, and expensive process. The measure of the producer's capability for operational research aimed at product improvement will be a useful guide, but it's no sure guarantee. Finally, the willingness of the producer to engage in frequent and frank exchanges of information about the product with educational practitioners, not through its sales forces but rather through the professional staff engaged in software design and

authorship, should be considered.

The product itself should be subject to rigorous scrutiny. Perhaps the most discriminating teachers on one's staff may be permitted to simulate learners in settings where the product is operational. These teachers can apply to the software the tests that they have commonly applied to textbook selection:

Are the contents of the program correct and accurate?

Does the substance appear to be compatible with our educational objectives, commitments, and constraints?

Is the program well-done from a technical standpoint? Are sound reproductions as clear as a live voice? Is the photography good?

Are written materials clear, readable, and within the vocabulary range of targeted students?

Are programed materials presented in logical and gradual progression?

Would the items stand alone as a satisfactory achievement test?

A qualified electronics engineer may be retained to assess the technical quality of the product and the costs of installation, repair, and maintenance. Similarly, an expert educational programer may be retained to evaluate the quality of the program. A subject matter specialist may be retained to assess the quality and relevance of the subject matter in relation to the school's educational objectives. The fees of these consultants may be returned several times over in guiding the school system toward sound choices.

This array of queries may appear disproportionate, and perhaps it is for some of the less sophisticated products. But if the price runs into five or six digits, the questions are certainly reasonable for most products. The salesman who cannot answer them is not prepared to sell his product. Manufacturers of educational hardware say over and over that they are prepared to produce what is needed. However, a corollary is also implied: "If you don't tell us what you need, we'll tell you what to buy." If educators leave to manufacturers the determination of the technology to be used, they will have little basis for complaint if the results are not to their liking. If the school administrator is unprepared to ask relevant and penetrating questions, he can expect the manufacturers to write his specifications for him. If the buyer surrenders to the vendor, the essential reciprocity of negotiation between buyer and seller—so essential to both product improvement and the free enterprise system—is abrogated. There is probably no better route to product improvement than the confrontation of salesman with buyers who are capable of asking the right questions; the

feedback between the salesman and the manufacturers is direct and compelling.

Questions on Research

It is beyond the scope of this statement to review the research on various components of educational technology, but brief comment can be made on the availability of such research. There has been a great volume of research on the mass media of instruction—principally educational television—but only a small volume of analytical experiments relevant to the instructional variables that affect the use of the mass media.

Although many studies have been made of the effectiveness of programed learning, it is difficult to assess or summarize this research because of the great variety of programs and modes of program interaction and the great difficulty of controlling the sizable number of variables. Although in wide use, language laboratories have not been the subject of much useful controlled research, and the hardware has run far ahead of the theory and research. Quite a bit of carefully designed and useful research has been done on instruction through use of motion pictures. Very little useful research has been done on the acceptance and management of educational technology, the primary subject of this chapter. Much more research is needed on the selection and management of instructional systems before the decision maker can make choices confidently.

The federal Commission on Instructional Technology reported that most of the instructional software commercially available lacks data based on objective evaluation. The Commission contends that methodology is sorely needed for the determination of the efficacy of material for various populations of students or for establishing empirical data on the relative effectiveness and efficiency of comparable texts.

While director of NEA's Project MATCH, George E. Arnstein concluded that there is not now in existence anywhere in the United States any single source of information and no reliable agency for keeping track of all experiments and demonstrations under way. However, the *Educational Media Index, Audiovisual Instruction,* and the *Review of Educational Research,* among others, frequently provide information that is useful in assessing the promise of various instructional systems and materials. Hopefully, the regional laboratories may in time provide useful operations research on many instructional systems that will yield valid and reliable information useful in selecting products.

Other sources of expert help may be on the not too distant horizon. One promising source is the Educational Products Information Exchange (EPIE) established to supply school ad-

ministrators with qualitative information about the performance of educational products. This nonprofit agency, still in its infancy, hopes to accumulate a substantial amount of detailed information on the objectives and performance of curricular products already available to schools and to organize and report this information so that it can be used wisely by school systems. How effective EPIE will be in this prodigious undertaking is still an open question.

It is hoped that the Cost-Effectiveness Evaluation Systems Model has provided a rational and disciplined approach to consideration of questions that must be asked about new instructional systems. It might be argued that the same rigor has not been applied to the systems of instruction in current use. However, the current systems must now be evaluated with the same care as new systems which might displace them. Although systems analysis is difficult and imperfect, one is nevertheless obliged to apply far more rational thought to planning instructional programs because the fateful decisions that must be made on educational technology will affect both the cost and the effectiveness of education for years to come.

6. Redefinition of Education–Industry Relationship

A not-too-uncommon assumption suggests that schools and industrial organizations have a known and mutually tractable pattern of relationships. The opposite stance is that each exists in peaceful isolation of the other's concern or influence. In the middle areas, a desire for mutually rewarding interaction is often expressed, without the necessary accompanying action. The vast diversity of education–industry relationships displays a real if unspoken alertness to possible undue influence or controls by the other side. Yet, all the while each side proclaims mutual dependence and a willingness to give support.

Proper doubt, then, may exist as to whether there ever has been a very easily defined or firmly established relationship between education and industry. Industry, for example, seldom sought the advice and counsel of schoolmen, and manufacturers did not keep the education market fully and regularly informed about products that could have educational implications. Even the educator's activities in the Chamber of Commerce and in the stimulation of Business-Industry-Education Days seldom are related basically to the prime responsibility of education: namely, instruction. Education in the past seems to have commanded limited attention among industrialists, except as a tax irritant and source of personnel. This AASA Committee corroborated the finding of the federal Commission on Instructional Technology, appointed by former President Lyndon Baines Johnson in 1968, that "educators have played little or no part in developing new products." [1] The past, however, need not be a deterrent to the development of the mutually helpful interaction that the impact of one enterprise on the other now seems to demand.

The Partnership Myth

The foregoing introductory paragraphs are not intended to register cynicism but rather to establish a better basis for exploring some rewarding interactions between education and industry. The AASA Committee believes that business and economic leaders must join with educational leaders to advance the cause of more effective educational programs in general, as well as to promote better learning through technology. This is also consistent with the recommendation independently arrived at by the federal Commission on Instructional Technology. Meaningful dialogue between industry and education is more important now than ever before because of the growing impact of the "education industry" on learning. The education industry is more than a prime cluster of textbook suppliers and secondary clusters of school equipment manufacturers. As technology increases its influence over school operations, so too will the producers of technological hardware and software increase their impact on education. As pointed out in an earlier chapter, the nation's schools are the biggest customers of the billion dollars plus audiovisual industry.

In general, each group has sought to maintain friendly relationships with the other, but has not sought a basis for substantial influence on the other's purposes, procedures, or outcomes. Participation in activities of mutual interest seems to have been aimed at attracting publicity rather than at promoting the central interest of the two parties.

Each group (industry and education) has developed its own trade or professional associations, which are built around self-selected centers of interest. Seldom have these associations been used for the purpose of interaction. Perhaps the annual meetings of the American Association of School Administrators have served better than most to bring together the exhibits of various developers and producers of educational equipment and the chief administrators of school districts throughout the United States. Superintendents have continuously agreed that the exhibits are their main interest at the national meetings. There has been less indication on the part of business and industry that their representatives sought out the educational presentations made in the convention sessions apart from the exhibits. There is no industrial counterpart in which the school administrators make a major contribution through any type of exhibit or presentation at a national meeting. This is not a matter of criticism of either or both. It simply indicates that there is a slightly one-sided effort to search for the point at which focusing can be a joint enterprise.

A possible strategy to promote the type of interaction was suggested by the federal Commission on Instructional Technology: the creation of a "National Council of Education and

Industry'' as a mechanism to bridge the gap between these two important segments of society in order to speed the advance of technology in education.[2]

As the schools become better marketplaces for the products of business and industrial technology and as the complexity of the instructional program becomes more visible and its failures less easy to conceal, educators have sought to encourage a mutuality of interests. This AASA Committee believes that business and industry in the United States can serve education by producing the learning tools and other equipment that educators cannot produce on their own. Neither teachers nor administrators have the competencies, resources, time, or inclination to design and manufacture language laboratories, 8mm projectors, computers, or any other device that could be used in the instructional process. A symbiotic relationship between education and industry should prevail, with each enhancing the contribution of the other.

Major efforts are required and have recently been initiated to bring about direct contact between the management interest of education and the management interest of industry. In the past, the contact mostly has been through the vendor who serves as an intermediary between the industry and the potential user. Past efforts to achieve interaction also included Chamber of Commerce activities and BIE Day, which are seldom more than social contacts. The purpose of such meetings is community development or social interaction. Since the nature of these relationships between top management in education and top management in business or industry is so informal and inconsistent, the benefits may be casual rather than substantive. Perhaps the elbow-rubbing of the past now may become a joining of hands. The objective should be to cause interrelationships integral to the development, production, diffusion, and use of the products of industry to serve the major needs of instruction.

Each party to the interrelationship has been characterized from time to time by what might be called ''power courting.'' Power courting entails seeking the cooperation of the other party when one sees some personal and organizational advantage that might be achieved. There is no way of indicating whether power courting has been initiated more by industry than it has by educational administrators. In any case it does not result in a creative, productive, or mutually helpful relationship.

Difficulty in working together has partially been a result of the unique administrative patterns of industry and education. The industrial group has a board of directors that is less constrained by legislated privileges, authorities, and duties than is the school system which is subject to a board which, in turn, is

subject to the controls of a legislature. This organizational pattern, however, does not necessarily pose an insolvable problem.

Most school boards are dominated by men from business, industrial, and professional groups. Many members of school boards consequently are either on, or in close contact with, the controlling boards of industry. Although the percentage of industrial chief executives in each group may not be high, school boards often have as members individuals from the second and third levels in the hierarchy of industry. The interrelationships and interactions here can be used as a basis for establishing a closer and more creative working relationship between top management in education and in industry.

There has been some degree of reciprocal influence by industrial and educational management. Educators have been influenced frequently by the precision and efficiency of business and industry. There is little doubt that, in turn, management in industry has been affected by the expertise found in the operation of school systems. Research in management techniques as well as in new product development has been concentrated in business and industry because they have been free to put money into various research efforts, whereas educators have not. To illustrate, in industry about 4 percent of net sales (approximately $18 billion a year) is dedicated to research and development. In contrast, educational institutions have research expenditures totaling no more than $25 million per year or no more than 0.25 percent of the nation's expenditures for schools. Business and industry have made many adoptions of personnel practices that have been developed in education; for example, testing individuals for job placement. Both advantages and disillusionments have grown out of the borrowing and adaptations. This disillusionment is resulting in an analysis of what really can be adopted appropriately and what can be used to stimulate the development of new technologies unique to the particular activity involved.

In Search of a Rationale

The limits of extrapolation are identifiable and definable but often well concealed. Much can be applied to education from industry and vice versa, but the trial-and-error period must be supported by sympathy and understanding on the part of each group. Perhaps we have come to the point where using what has been used by someone else is not deprecatory to the individual doing the borrowing. Luckily, values are altering in this complex society so that accomplishment can be considered more important than uniqueness. If this type of mind-set can be established mutually, a greater respect for differences may well develop, and the demand for commonality may be relegated to its proper place among the less consequential attri-

butes of industrial and educational management.

There have been enormous profits in uniqueness. There still are and perhaps always will be, but uniqueness should be the by-product of recognition rather than a goal. If this concept of uniqueness can be applied to the interaction between industry and education, perhaps respect for differences can be cultivated. The respect for differences, in turn, will provide a better basis for judgment and selection of extrapolations that may be mutually beneficial.

The competitiveness of free enterprise as known in this country long has been credited as one of the factors contributing to the rapid development of technology. We are beginning, however, to recognize the social implications of generalized competitiveness—its dangers as well as its benefits. Generalized competitiveness can encourage wholesome attempts to improve, but it can also generate a meaningless competition between unrelated activities with noncomparable goals and products. There have been many occasions in which industry and education have let competitiveness become generalized. The result has been that the two enterprises remain separated and without mutual understanding.

The growing inclination of industry and education to find commonality of interests and mutuality of helpfulness is based upon the long-delayed realization that one does not have to destroy another in order to feel a sense of assurance. Other factors, particularly the actions of federal agencies, have done much to bring about a rationale that encourages industry and education to be mutually supportive. The federal government has not passed laws or instituted regulations to force it. The primary inducing agent has been money (often called a potent social lubricant), because technological development for instruction requires enormous sums of money which only the federal government seems able and willing to venture. Government appropriations have become the vehicle through which industry and education can establish and pursue profitably an interaction that supports development in industry as well as better and more potent procedures for the instructional tasks of the school.

Many people raise the question now as to whether education or industry has profited more from this relationship. The important thing is that educational problems are being attacked at the present time and that industry's capacity and ability in the areas of research and development are playing an important role in this attack.

A hopeful and yet fearsome development at the present time is the mergers that are taking place between the hardware industries and the educational software industries. Mergers between electronics firms and publishing houses are signs of

the mutual need in the present relationship between education and industry. The needs of educators should be kept in mind by the hardware industries. Those who are developing the hardware ought not to continue its development for business and industrial use only and then expect education to adapt its procedures to the existing hardware, thereby creating another market for the hardware. The need for appropriate software to justify the existence of hardware has stimulated these mergers. However, unless management exercises some initiative, the mergers may become restrictive of the instructional program.

The inclination to merge industries into so-called conglomerates constitutes the potential problem. The combining of hardware and software producers, such as electronic and publishing enterprises, may become so comprehensive that the potent control factor of competitiveness is lost. The loss of competition among industries easily can result in the schools' loss of control over the design of and procedures in the instructional program. If the conglomerates also gain control of the communications media, then the schools may lose their opportunities to remain sensitive to the public that created and maintains them. Claims for greater economy and superior products notwithstanding, loss of control over the purposes and designs of instructional programs is too high a price to pay. Vigilance to this danger is essential. These are present problems which have grown out of what appeared to be promising ideas.

The movements described above in the search for a rationale for the future lead unswervingly to the fact that we are entering a period of increased centralization of instructional controls and developments in education and industry. These relationships, in part, are the result of larger and larger capacities for productivity on the part of industry and the larger and larger districts that have been created for school purposes. As the districts grow larger, local control, so treasured in the past, grows less. As people become farther removed from the controlling boards and as the population increases, the ease with which an individual may express his opinions about education decreases. Largeness, however, has compensating aspects, such as streamlined communications facilities and increased prospects for more manageable markets. The same type of phenomena appears in industry: the "man on the street" is farther removed from the management and, thereby, from the controls. Another pattern of centralization results from the activities of the federal government. In supporting and centralizing controls, it puts certain requirements and restrictions on the use of federal monies. These, in turn, restrict the autonomy of both schools and industry. These strengths and weaknesses of centralization may be potent and significant factors in the increasing close

alliances in the relationships of industry and education.

Centralization brings about commonality and uniformity. The rationale that may be developed at the moment is that there is strength in joint and coordinated interests and efforts. There are increasing signs that industry and education have been viewing each other with some reserve. They now must do more than view each other. The fact that industry and education are becoming increasingly dependent on each other becomes a part of the rationale for a basis of good relationships between them. By keeping in focus its own resources, each will be able to solve bigger problems, to perform more effectively, and to achieve its unique goals with greater satisfaction. Thus, the rationale should include the maintenance of self-interest, which will keep each group in check. Self-interest thus need not be equated with selfishness or exploitation; rather, it can be looked on as the guarantee of the mutual policing that probably will help keep the original and proper goals in view.

Those who see danger in the merging of either corporate interests alone or of corporate with public interests, such as education, should speculate also on the dangers of separatism. Our past is replete with instances of the separatism of education from almost every other profit and nonprofit activity found in our society. That separatism, perhaps, was a protective device that permitted educators to live with their strengths and weaknesses without review and without challenge. Industry often faced the same criticism. In the past, industry has been described many times as the exploiter and the antagonist of the larger public interests until checked and penalized through legal processes. However, this criticism is no longer completely valid, because industry has taken many steps to initiate a closer relationship with education. There is a loss of resources as a result of separatism that is mutually disadvantageous. The destructiveness of the unchecked and wrong-goaled competition for dollars in the past should not be used as an argument against centralization in the present. Separatism leads to a wasteful overlap that, in our society of so many needs, cannot be justified. If industry, with its research and development facilities, can serve the needs of education as well as those of the steel industry, for example, then, to the extent that commonality of interests exists, it would be wasteful for education to proceed on its own. Similarly, when industry is having increasing problems with respect to the management of personnel, it should be able to benefit from the expertise of the educational establishment in this area. The mutuality of goals and the negotiation of the rules of relationships can prevent the destructiveness and wastefulness of the past. Separatism as the basis for carrying out the activities of industry and education can lead to nothing other than outside controls for both.

The federal government stepped into the education picture because of financial and developmental needs. It was only in part that the federal government sought, through its funding of cooperative enterprises between industry and education, to control certain social factors. Whether one likes the purpose of those controls is of little consequence in the rationale being developed here. They exist, and they have not destroyed the potential of education–industry cooperation. As stated earlier, a recent federal study commission called for more formal mechanisms at the national level (i.e., the "National Council of Education and Industry") to continue such interaction and cooperation. It must be recognized that to the extent education and industry cannot manage a proper relationship in research development, diffusion, and use, outside controls may be forthcoming. This is not speculated on as a threat, but rather as a hard fact. The federal government has the power to impose many more regulations that will condition the relationships between education and industry. However, if the two prefer to be free to manage their own interrelationships, they can do so, although it seems less likely in view of the Commission on Instructional Technology report. As outside controls are placed on this interaction, there will be an invasion of decision prerogatives. The competitiveness described earlier could result in a contest for decision prerogatives that would stimulate each other's assumption of autonomy. To the extent that this happens, there is an undesirable modification of purpose. However, industry and education can preserve their individualized purposes and pursue their self-selected processes while finding ways for harmonizing and coordinating the general social purposes as well as the quality, nature, and use of the products of each. This takes a conscious, intellectualized effort on the part of both education and industry. It is reduced, then, to the issue of whether management in each sphere of activity is willing to think in terms of interaction rather than of separatism. Present practices indicate that the rationale suggested here is being accepted, and perhaps both groups are finding it rewarding enough to enter into interaction to an ever-growing extent.

Unique Domains of Industry

Each organization, in order to maintain its self-respect and prestige, must identify certain nonmonetary factors in its self-determination. Industry does take in a number of other considerations in the selection of purposes, in the procedures by which it shall accomplish the purposes, and in selecting the target for its efforts. The determination of purpose in industry, however, is most seriously affected by markets, which are essential to the maintenance of industrial organization and effort. If the markets do not exist, a certain amount of self-determina-

tion is exercised in the creation of markets. Industry often cannot control the fact that markets are lost, but it can control its own efforts to hold or to create new ones. Thus, one characteristic of industry is that it either prospers or fails according to its abilities and efforts.

In the past there have been some misunderstandings about the privileges of any group that pays the bill. The old cliche that "he who pays the piper calls the tune" is as true and as limited for industry as for any other enterprise. Industry pays a substantial bill for the services of government, which allows it to exist safely and rewardingly. Industry also pays substantial amounts for the maintenance of educational programs. This has led to the assumption that industry can dictate the purpose, nature, and direction of the instructional program. This has been less true in recent decades than in the more distant past of education in this country.

The entrance of the federal government into the realm of education by virtue of its major support and concomitant regulatory powers has significantly altered money-control presumptions. At this point industry lost some of its independence in determining purpose and procedure vis-à-vis education. With the government as a contributing regulatory agency, the situation is quite different than it was when industry dealt directly and solely with school systems as major purchasers of products. Since the schools possess no regulatory powers, there undoubtedly were many instances of exploitation by industry. The competitiveness among industries has more or less corrected this inclination to exploit any market. The increasing sophistication of the purchasing public has called for improved ethical standards on the part of industry.

Another domain in which industry is relatively free from tampering by outside interests is its discovery and development activities. Industry has control over its budget and personnel. Industry is not constrained to limit the broad array of interests that it may elect for research and developmental work. Industry has a prerogative held by almost no public agency such as education—it can be more objective about its failures. The schools labor under what may be termed a "positive result anxiety." If schools try something new, it must be right the first time. This has been a deterrent to the development of new educational ideas and material.

Industry's objectivity about its failures has been one of the strengths that make it possible for industry to be a better creator and developer of educational devices than the educational organization. Even universities, with their assumed freedom from control as compared to elementary and secondary schools, have been, nevertheless, under greater controls and regulations than industry. The recent years, in which much research has

been contracted by the universities, reveal little change in this particular picture. Industry also has more control over the information that it releases about its developmental work.

Industry has substantial autonomy in the choice of its manufacturing procedures. It can choose locations, personnel, manners of quality control, and can establish production quotas. These factors are seldom threatened by outside forces, but some autonomy can be lost through zoning regulations and labor organization actions which have been legislated or negotiated. However, these types of controls seem not to have been a serious deterrent to the research and development aspects of industrial contributions.

Industry has great autonomy with respect to the distribution of its products. It can determine pricing, advertising procedures, wholesale-retail policies, service guarantees, and many other aspects essential to a successful enterprise. However, each of these has been threatened from time to time by such things as fair pricing, honesty in advertising, and wholesale-retail pricing regulations, and, at the present time, by investigations of service guarantees. Even with these periodic and perhaps somewhat frustrating invasions of its domain, industry has great autonomy. It is free to develop personnel for jobs that seem quite antagonistic in purpose and method. An illustration of this is the personality of the salesman as contrasted with the personality of the claims adjustor. But few have assumed that industry should abandon its own major purpose to become altruistic in its total operation. In fact, altruistic industries often experience a short lifespan. Nonaltruistic postures are not to be considered equivalent to hypocrisy in representation of purpose and product. Simple logic accommodates the prerogative of industry to maintain enlightened self-interest, and this, in turn, is a secondary support to many activities in society.

A final characteristic of industry is that it employs students from the schools. Very often the taxpayer role of industry is overemphasized to justify industry's demands on the schools. As a matter of fact, industry simply calls on the schools to teach skills necessary to a commercial enterprise. This seems no more improper than for a church organization to want the schools to provide the kind of an education that makes the church's responsibility easier to meet and more effective. The schools serve all elements of the population and expect to receive statements of expectations from each of them. There are, however, the general and the specific personnel needs of industry that must be considered. There seems to be little agreement as to whether the schools should provide a generalized type of education and leave the specialized type of training to industrial inservice activities after employment. Some people contend that it is the job of the high school to teach many

different skills so that industry will not have to assume the burden of giving specialized training. The issue is really a contest between large and small industrial agencies, for only large industry can afford to budget for and direct the training it needs for its employees. The schools, then, are caught between the opposing demands of large and small industry. Education has not yet found a way to serve both interests. The employer is free to offer criticism about its employees to any audience. As a result, conflict frequently has been generated between industry and education because industry has communicated to the general public, rather than to just the schools, its dissatisfaction with the schools' product from the standpoint of its employment needs.

There are many other prerogatives of industry that could be cited. The ones indicated here are provided for the purpose of comparing the domains of industry with those of education.

Unique Domains of Education

The preceding section indicated that there are certain prerogatives for industry that seem unique and almost incontestable. Schools likewise have some of these characteristics, although they are different in nature and source. One of the most important unique characteristics of schools is their legal assignment to develop and direct the educational program. Other agencies may express opinions and make demands, but the schools have been charged with the major responsibility for determining the nature of the educational program. This means that the schools are quite independent in curriculum determination. There are few outside pressures or controls with respect to whether the emphasis shall be upon the cognitive, the affective, or the psychomotor areas of learning. The emphasis and balance among these areas is a matter for the professional educator to determine. If taxonomies are to be developed in determining the best selection of educative experiences for each of the taxonomic levels, that is the prerogative of the professional worker. The methodology of instruction used in the classroom is under the almost complete control of professional personnel. Outside protests can be made about the textbooks in use, phonics, grouping, and many other of the aspects of management of instruction, but protests seldom grow into legislation. Therefore, there are very few instances in which this particular domain has been infringed upon by nonprofessional and nonschool agencies.

The schools have great latitude in the selection of the facilities required to support the instructional program. When industry develops a piece of hardware or software, it still must be subjected to the scrutiny of the proper officials in the school organization. It would seem, then, that the schools persist as a

major independent agency, even though created by the state and having many federal regulations placed upon them. Not long ago many of the states had statewide textbook adoptions even when there were no multiple text adoptions. This was a type of centralization of the control often dominated by non-professional people. State after state discarded the practice and, thereby, released the schools to be self-determining with respect to this particular aspect of the instructional program.

The totality of school activity may be viewed in terms of three categories: namely, goals, processes, and products. The goals of education are not determined exclusively by the professional personnel in the school organization. They are a matter of shared choice—shared by the professional educators and the supporting public. The products of education are a matter of shared evaluation, although the schools make a determination of the appropriate terminal behavioral characteristics of the pupils. As indicated above, industry, as well as many other agencies in society, determines whether the products of the school are acceptable to its particular purpose. So the goals and the products are not completely determined by professional educators. The processes, however, fall almost entirely within the domain of the schools. This means that the major choice of the day-to-day activities, including the selection and acquisition of hardware and software, resides with the professional personnel of the school, who face no threats at the present time in this area.

The implementation of changes in instruction is dependent on the ability of the staff, as well as financial support and public acceptance. This is less clearly an area of autonomy or self-determining action. It can be said, however, that education, like industry, can point to many elements that it determines.

Overlapping Concerns

The broad social goals of the schools certainly are the overlapping concern of industry and education, just as industry's economic goals are subjected to the appraisal and influence of many agencies other than industry. Whether either industry or education likes this state of affairs is of little consequence. The point is that this is the situation. It can better be used than defied.

The broad scope of interrelationships between education and industry is affected by the influence schools have had on the management of industry, since management itself is a product of the schools. It is time that both sides stop viewing with alarm what are considered to be infringements from one side or the other. Industry as a taxpayer is not a threat. It is, in fact, just the opposite. Schools as a conditioner of the quality of industry are not a threat but rather a supporter of industrial

purpose. Both groups find common ground in civic loyalty. Perhaps some popular writers have found rewards in referring to industrialists as "merchants of death" or school people as "pink citizens." Such unwarranted depreciations merit little attention when considering the overlap of the broad social goals of the two.

There is a common interest to be found in the economic profits of industry and the support that industry gives to the schools. Likewise, schools furnish trained personnel and markets for industry.

Unlike industry, schools cannot develop research laboratories that provide the materials that instructon has increasingly demanded. Were it not for interaction between industry and education, many of the recent major advances in the instructional program would have been impossible. In turn, industry needs wide acceptance and adoption of those things that it invents, develops, produces, and distributes. The schools are becoming a lucrative market for industries promoting developments in instructional programs. This constitutes another advantage of interaction.

As society becomes more complex, the more urgent it is that appropriate management procedures be developed. Industry is a complex organization; a school is also a complex organization. Each requires many levels of management, and each requires specialization of its personnel. To the extent that there are overlaps, industry and education have common concerns and common grounds for study and development. The interchange studies in management and procedures as indicated earlier in this chapter should be recalled at this point. The development of staff personnel by schools and industry has many points in common. One of the reasons for some absence of overlap of concerns in personnel development and management is that the schools are dealing with a much higher percentage of professional people than is true in many industries; this is less true now than a few years ago. There is increasing evidence of overlapping concerns in the area of personnel because of the technical and specialized requirements of industry as well as those of education. So long as industry and education do not try to overextrapolate the processes of their agency efforts, then the overlapping concerns can be rewarding.

To maintain, as is occasionally done, that there should be as much quality control in the schools as there is in industry is sheer folly. Regardless of an imaginative drug industry, the reproduction characteristics of males and females will guarantee a variability of input for the schools that defies the most sophisticated control devices. Industry on the other hand has great control over the kind and quality of products that go into its production machines. Thus, so long as we can see the overlap

in the broad goals of industry and education, the processes of each can be maintained with a broad scope of autonomy. The products cannot be compared directly from the standpoint of quality control.

An interesting historical observation is that industry long has made use of consultant services. This consultant service often has come from the ranks of education. It would appear then that industry is substantially ahead of education in expressing its confidence in the unique contributions of the other. Education has been reluctant to use industrial personnel as consultants. To date the schools have used more consultant service from the universities than from industry. The schools, however, have used consultant service from organizations that make a business of consulting. This type of consultant service usually has been limited to building, financing, and, to some extent, organizational design. Few of the professional consulting agencies are capable of directing their efforts in a rewarding way to study the instructional program. Education must shake off this reluctance to share the mutual confidence that industry long has invited. If school people are afraid that industrial representatives will scuttle the basic procedures of education, they should bear in mind that educational consultants long ago could have scuttled many of the efforts of industry. This did not happen, and there is no reason why an industrial consultant would want to deter an instructional development. Here is an area where overlap should be encouraged.

The more that interaction can be stimulated, the more will mutual respect increase. As respect increases, there will be a greater sense of security in the interaction. The notion of the Trojan Horse in this context has been overworked and should be abandoned. There is no reason to suspect that an educational consultant in industry or an industrial consultant in education is there for any other than a positive contributory service. Industrial executives at the top level have greater latitude in employing immediately needed special assistance than do superintendents of schools. The industrial executive may get specialists of all types to serve on his immediate staff. Superintendents either have been reluctant or have been unable to secure specialists in various aspects of administration to work closely and exclusively in their offices. Superintendents have found it easier to get additional staff with responsibilities for supervision or direction of the classroom instructional program than to get the technical personnel their offices now require. Boards of education must share a major portion of the blame for this inadequacy in staffing at the superintendent's level in the school organization. When this situation is corrected, security will be less of a problem, and one of the great barriers to mutually beneficial activity and concern between industry

and education at least will have been removed.

Marketing Policy and Dissemination

It was pointed out earlier that industry has a degree of autonomy in determining its marketing policy and dissemination procedures.

Industry has available to it any number of communication procedures. Among these are mass media outlets, personal contacts with known change agents, and advertising contacts that can be achieved on a broad basis. Industry attempts and has considerable success in gaining product visibility. (In the area of education, the exhibits at the annual meeting of the American Association of School Administrators, mentioned earlier, are particularly useful.)

The purchaser, on the other hand, must try to discriminate between the fast-buck operators and the long-term developers. Industry has not developed adequate procedures by which to police itself. Industries that want to stay in existence for a long time are handicapped by the ones that are willing to deceive or to pressure and then get out of business with quick rewards. School officials must not indict all industry because of an errant minority. Schools, too, have some problem characters within their folds. The public has on occasion accused some schools of "peddling the emperor's clothes." The unprincipled element in each group constitutes a minority, but a minority that must be eliminated or subjected to controls that will make it possible for the legitimate operators to continue.

A part of the marketing policy and dissemination procedure that has been grossly neglected by industry is that of making available appropriate field test data. During this Committee's study of the relationships of technology and instruction, many industrial producers were contacted and asked for field test data. The answer often came back that such data were available but had not been summarized. They had not been summarized because superintendents and purchasing agents had not requested them. Thus, if we point an accusing finger at industry at this point we must likewise point an accusing finger at educators. Perhaps a profitable common effort here would be to develop more field test data and use them to determine the appropriateness of purchases at the local school system level.

Market Resistance and Product Analysis

The counterpart to industry's concern with marketing policies and dissemination procedures is the superintendent's resistance to or selection of particular technological products for local school requirements.

A study is currently being made of the relationships of cer-

tain personal reactions to resistance to marketing pressures and to the procedures by which technological hardware related to the instructional program is selected. Such factors as frustration, emulation, expediency, and prestige will be explored. Attention is given at the same time to selection criteria in the areas of instructional policies and procedures, equipment specifications, and vendor–purchaser ethics. There probably are many reasons why superintendents respond to corporate pressures in the way that they do. One response—accepting an innovation because one is weary of corporate and professional pressures—is not valid. Emulation often has been a stimulator. Research has shown many, many times that people are influenced by what their neighbors are doing. Emulation, like submitting to pressure, is an inadequate basis for arriving at decisions. This is not to say that anyone ought *not* to do what his neighbors are doing, but that he should have other and sufficient reasons for doing so. Expediency may take the form: "Since we can find nothing better, this will do."

If industry builds up the prestige of its product in the community, then prestige becomes an increasingly important factor. Keeping an educational program up-to-date is a proper rationale for a superintendent, providing school funds and instructional staff justify the use of technological devices. The major focus in product analysis must be in terms of its contribution to learning and instruction. This calls for a review of the selection and procurement policies and procedures characteristic of each individual district. Superintendents must be skilled in this area of interpretation.

No longer can administrators purchase a major piece of equipment, deliver it to the classroom, and tell the teacher to make good use of it. The dangers of this approach have been exposed time and time again, and most administrators are well aware of the impossibility of such an approach.

One of the more difficult tasks of the superintendent is to establish proper criteria for the selection of technical equipment. It is difficult to determine the mechanical sturdiness or technical efficiency of a device merely by looking at it, by listening to it, by touching it, or by reading descriptions of it. Some assistance is being offered at present by a new educational products evaluation system. This service represents a start in providing the superintendent with specific information that should help in arriving at better judgments on the quality of equipment.

The time is past when an industry could depend simply on getting a local agent who succeeded in selling the firm's products solely on the basis of customer's loyalty to him as a "local boy." Industries at present are operating on a larger scale than the use of local vendors permits. This does not mean that we

see none of it at the present time, but that we see considerably less of this approach now than was the case. Much more effort is being put forth now on the part of both professional educators and industrial representatives to operate on the basis of knowledge.

The federal Commission on Instructional Technology reported on the problems encountered by schools seeking to adopt technological devices at this point in time:[1]

1. Many technological devices designed for specific and noneducational processes require significant adaptations to maximize their usefulness in schools.
2. Hardware pricing policies are keyed to the commercial market, which makes it all but impossible for many schools with budgets carefully reviewed by taxpayer groups to purchase products of the new technology.
3. Some kinds of equipment are found in abundance (e.g., movie and overhead projectors) but are largely unused or underutilized, whereas other types of needed devices (e.g., computers) are scarce items in most schools.
4. The supply of instructional programs to make technological hardware operate is inadequate.
5. The quality of instructional "software" developed to date is relatively poor.
6. Instructional "software" is so inflexible that often material designed for one machine cannot be used on a competitor's model (e.g., one company's videotape recorder will not accept another firm's tapes).
7. Many devices are too complex to be used by most teachers, and maintenance for all-too-frequent breakdowns compounds the problem.
8. Field testing of new hardware before marketing is minimal, and little validated evidence exists to guide purchasing decisions.

Interaction Code and Ethical Behavior

An encouraging development at the present time is that there are many intragroup association agreements and disciplines. Vendors are organized; industrialists are organized and do, within reasonable limits, exercise some influence on their associates in the field. Often this influence is effected through the development of a code of behavior. The major problem is that few of these agencies have the necessary power to discipline, other than to expel an offender from the association. As the associations increase in recognition and in public confidence, they gradually will increase in the power they wield over their individual members. This will not affect the "wildcatter," since we do not have ways of controlling all of mankind's behavior. The point here is that the intragroup association is doing much

better both within the educational profession and within industry.

There is some effort—albeit a feeble one—to provide intergroup association agreements and provisions for discipline of a typical practice. It is time now that the industrial and distributor associations achieve solid interdependence by joining with the administrator associations in an effort to explore ways in which they can be mutually helpful and protective. The openness of each association group in approaching the conference table may be the guarantee of a progressive type of activity along this line.

Closing on a negative note is never appropriate, so the above is offered as a suggestion rather than a threat. The sooner this intergroup type of activity is organized and the more extensive it becomes, the less likely it is that control will be exercised by a third agency, such as a governmental unit with regulatory powers. We don't mean to suggest that regulatory powers are, in themselves, bad. It is our contention that self-regulation is more in the spirit of the American way and that this is a more positive way to approach interaction between industry and education.

This AASA Committee concurs with the federal study Commission on Instructional Technology that cooperation between education and industry requires changes in certain attitudes and approaches. For example,

1. Industry must be willing to—
   a. Forego immediate profits and concentrate on development of equipment and materials for the long-run.
   b. Abandon the belief that because a product sells well it is educationally sound.
   c. Develop intensively a limited number of products proven to be effective in instruction.
   d. Work with educators to develop and redevelop materials and equipment.
2. Educators must be willing to—
   a. Define instructional objectives with the clarity necessary to define material and equipment demands and then to use the produced items.
   b. Help test new approaches and persevere with innovations until properly evaluated.
   c. Acquire the necessary understanding of technological innovations.

Footnotes

1. Commission on Instructional Technology. *To Improve Learning.* A Report to the President and the Congress of the United States. Washington, D.C.: Government Printing Office, 1970. 124 pp.
2. *Ibid.*
3. *Ibid.*

Other References

1. *Educational Product Report.* All issues. Published by the EPIE Institute, New York, N.Y. (P. Kenneth Konoski, editorial director.)
2. Kuhn, A. Joel. "Corporate Pressures on Educational Innovation." Ph.D. dissertation. Madison: University of Wisconsin, 1969. (Unpublished.)
3. Ridgeway, James. *The Closed Corporation.* New York: Random House, 1968.
4. Robertson, S. Thomas. "An Analysis of Innovative Behavior and Its Determinants." Ph.D. dissertation. Evanston, Ill.: Northwestern University, 1966. (Unpublished.)

7. Instructional Technology Reshapes the School: Its Impact on Faculty and Administrators

It is an intriguing but difficult task to examine the impact of technology on the local educational system. What will be the role of the teacher in the forthcoming age when technology will play a dominant role in learning in a school setting? What happens to the role of the principal under such conditions? Of the superintendent? What new educational specializations will emerge? How will the professional staff and students be deployed? What will be the effect of technology on attendance areas and administrative units? And, finally, will the school itself survive or will it be replaced by a new social institution with educational purposes? The answers to these queries are not easy to come by. Speculation provides the only answers at a time when technology is still a primitive art in education. Nevertheless, it is well to remember Galsworthy's warning: "If you do not think of the future, you cannot have one."

Reshaping the Role of the Teacher

Thomas Edison may have been the first to comment on the impact of technology on the role of the teacher. In 1891, he predicted that his motion picture projector would eliminate the need for teachers. Sixty-seven years later, Alexander Stoddard, then with the Ford Foundation, was quoted in the *New York Times* as saying that nationwide use of television could save 100,000 teaching positions and half a billion dollars in teachers' salaries annually. Since then, however, other articles by educational technology enthusiasts have assured readers that the machine will not replace the teacher. These assurances are so categorical and confident that one wonders whether the proponents of technology, like the Queen in *Hamlet,* "doth protest

too much." As the federal Commission on Instructional Technology [1] puts it, the public and the education profession have been bombarded by optimistic predictions that technology will quickly transform schools and colleges. The legacy of the Luddites and the fear of the machine as a threat to human employment were manifest in many occupations before they were manifest in teaching. This has prompted some to speak to the myths of instructional technology.

Will the machine replace the human teacher in the classroom? One is reminded of the argument of the scientist and the humanist over the relative capabilities of the computer and the human mind. The scientist extolled the virtues of the former: it is faster, more accurate, requires no vacations, demands no overtime pay, requires no psychological ingenuity in its management, and is unconscious of status. The humanist conceded these advantages to the machine, but insisted that the human mind had three incomparable advantages: it is highly mobile, it requires relatively little maintenance for an average of 70 years of service, and finally, its greatest advantage, it can be mass produced by relatively unskilled labor.

Will the machine replace the human teacher in the classroom? The experts give no clear answer. Suppes, of Stanford University, one of the pioneers in the development of CAI, states confidently that there seems to be little reason to think that computers will ever replace teachers or reduce the number of teachers needed. However, Broudy, of the University of Illinois, believes that the machine will displace the teacher because, to some extent, the machine will be doing what a live teacher might be doing. There would be no profit in machines if they did not somehow replace human labor. Most of the widely quoted authorities on this issue believe that technology, at least in its present prototype form, will not displace live teachers. Reports of school systems' experience with educational technology do not as yet reveal any reduction in teacher-student ratios as a consequence of the introduction of most new technology. The federal Commission on Instructional Technology reported that school teachers in 1969 were beginning to see the value of using technology, but few teacher-training institutions gave even passing attention to technology.[2]

Will the role of the teacher be affected by the use of educational technology? The literature provides no decisive answer. Some authorities argue that the teacher's role will be more significant and professionally challenging primarily because it will be the teacher's responsibility to prepare materials for the machines—programs, televised lessons, filmed demonstrations, audio and visual illustrative materials, demonstrations, and evaluation instruments. Others contend that machine-mediated instruction will be "teacher proof"; teaching and curricular and

instructional decisions will not be made by teachers but by the producers of the materials and the controllers of media transmission.

Will educational technology relieve the teacher of his role of tutor, or will it make him a full-time tutor? Broudy contends that under ideal conditions teaching machines will function as a surrogate for the teacher in the "tutor-tutee" relationship and will instate this relationship for all pupils equally. Previously, because it was the most expensive of all forms of instruction, it was restricted to a very few. Coulson, of System Development Corporation, on the other hand, contends that the teacher will spend most of his time in diagnosing individual learning problems and remedying them in close tutorial interactions with pupils.

Suppes believes that computer-assisted tutorial systems, particularly in the well-structured subjects such as reading and mathematics, will carry the main load of teaching those subjects and that it will be the teacher's responsibility to help students who are not proceeding successfully with the tutorial program and who need special attention. The teacher's major task in this circumstance—that of salvaging the machine's failures—is perhaps less exhilarating than the teacher's present role. Although there may be challenges in becoming a remedial specialist in the skill subjects, the teacher presumably will no longer enjoy the satisfactions of guiding the learning of able students. The ultimate effect on morale of teachers in this role remains to be measured.

One of the most enthusiastically proclaimed advantages of the new technology is that it will liberate the teacher from many of the pedestrian tasks of the classroom—preparing lessons, correcting papers, and recording grades, among others. This blandishment is alluring indeed, but the amount of routine work required, even in computer-managed instruction systems, is still an open question.

New patterns of deployment of live teachers, various specialists, paraprofessionals, and machines will undoubtedly emerge. Joyce has proposed an organizational model which illustrates one of the various possible "man-media-machine" systems.[3] The model consists of a "direct instructional team" and "support centers." The instructional team includes the team leader, an assistant team leader, other teachers, and several paraprofessionals, including interns and teacher aides. This direct instructional team is supported by specialized staff and technology from (a) a computer support center, (b) a self-instruction center, (c) an inquiry center (a library with abundant materials for listening and viewing), (d) a materials creation center, (e) a human relations center, and (f) a guidance and evaluation center. These centers, which support several direct

instructional teams, employ computer programmers, media specialists, counselors, writers, and other specialists, in addition to paraprofessionals. The model includes a teacher leader who is not simply a master teacher in charge of a conventional teaching team but the leader of a large and complex staff. This leader "orchestrates the environment" of rich resources of specialists, media, and machines so that curricular patterns are tailored to the unique needs of individual students.

Will teachers survive the teaching machine and the computer, as secretaries have survived the typewriter and the dictation machine? Or will they go the way of the blacksmith and the coal miner? If teachers do become organizers of systems of instruction, coordinators of media and methods of instruction, authors of instructional materials, diagnosticians of learning difficulties, and prescribers of remediation, there is a chance that teachers will eagerly seek the allurements of educational technology. But if teachers become simply button-pushing robots, clerks in instructional supply rooms, or scavengers of the machines' failures, then their resistance to the "technological revolution" in education will be understandable and probably effective.

Clearly it is too early to answer these questions. Much more experience and research are needed before final decisions can be reached regarding the optimum deployment of human teachers, media, and machines. Educational theorists have spoken freely of the idealized role of the human teacher as an exemplar of scholarly behavior; a leader of cooperative inquiry; a guide of students' intellectual, social, and emotional development among others. Judging from available studies of teacher behavior, very few teachers fulfill these roles sufficiently well. The importance of better research on the effectiveness and improvement of human teachers, particularly by those concerned about the humanizing of education, can hardly be overemphasized.

Important as the future role of the teacher may be, this consideration is clearly subordinate to the more compelling question of whether the machine or human instruction or some combination of each contributes most to the total development of the learner.

Reshaping the Role of Specialists

Educational technology will require the services of specialists not commonly employed in traditional programs of instruction and will modify or perhaps eliminate the roles of others.

This point is consistent with the observation of the federal Commission on Instructional Technology. To quote this Commission,

Technology can achieve its fullest potential in schools and col-

leges only with technical and paraprofessional support—"media coordinators" serving as advisors on the use of instructional technology, experts on the production and procurement of instructional materials, plus specialists in many different disciplines working with teachers in research and development.[4]

In the next breath this same group observed that the lack of such specialists "could well be the Achilles heel of instructional technology." The scarcity of quality programmers handicapped the development of programed instruction presented with or without machines.

Some attribute the downfall of the so-called teaching machines in the early 1960's to poor programing. Personnel with the competency necessary to produce quality instructional materials for modern technology are still in very short supply.

The installation of more sophisticated educational communications systems will require various kinds of media specialists with strong technical training in such fields as broadcasting, television, audiovisual projection, photography, sound recording, and related technical fields.

Many school systems will probably need an "educational engineer" to supervise and to coordinate the work of these communications specialists. Ideally, the educational engineer will have general knowledge of technical aspects of communication engineering and general professional knowledge of instruction. The closest existing counterparts to the "educational engineer" are probably the coordinators of instructional materials centers, many of whom began as audiovisual coordinators. Whether the coordinators of instructional materials centers (whose backgrounds are typically stronger in pedagogy than in engineering) can acquire a technical competency in communication engineering for this new position is an open question. If not, we may turn to the schools of engineering rather than to the schools of education for recruits for this new position.

The installation of computers will require the employment of programmers—people who can talk to the computer. These people will be subprofessional, but with salaries and status well above the clerical level. The programmers' skills will be narrow but precise and important and will require a moderately high intellectual level. Within this classification, subspecializations will probably emerge in such areas as instructional programing, information storage and retrieval, research, and others. This group of paraprofessionals will require mastery of the science of programing but not of pedagogy or subject matter. Their work will be supervised by specialists in computer-assisted instruction who are capable of linking computer capabilities with the problems of curriculum and instruction. These specialists will articulate the work of technicians and teachers and will

themselves be expert in both technology and pedagogy. They will supervise the preparation of instructional materials for transmission through the instructional media. One of the CAI specialist's most important roles will be to advise the school district on the purchase of instructional software. These specialists will serve as change agents of the enterprise, identifying worthwhile new technologies and relating them to the district's educational goals. This position may preempt many of the responsibilities now held by curriculum directors, assistant superintendents for curriculum and instruction, coordinators of curriculum and instruction, and similar functionaries. Whether the present incumbents of these positions can acquire the new competencies required or whether they will be replaced by a new breed of "coordinators of computer-assisted instruction" remains to be seen.

The most sophisticated specialization to emerge from educational technology may be that of the "systems analyst." He may serve in a staff position analogous to the research and development officer found on many university administrative staffs or in a line position analogous to the vice-president for research and development in many industrial corporations. The position of systems analyst has no precursor in public school organizations, which have been notoriously unmanned to undertake operations research, the forerunner of systems analysis and systems management. Whether this new functionary will serve in a staff position, advising and serving the administrative organization of the school system, or in a line position, perhaps as deputy superintendent of schools, cannot yet be predicted. In either case, this will be a position of potentially enormous power in the school system. Its incumbent will sit at the nexus of communication and the locus of decision making in the school system. He will bring an intellectual discipline to decision making that may be little understood by most of his administrative colleagues and therefore difficult to refute. The present short supply of systems analysts is jeopardizing the full and rapid application of systems theory to educational administration.

What the place of present specialists in conventional school organizations will be in new organizations is not certain. Supervisors of teachers, as we know them today, will probably become increasingly obsolete under systems of educational technology. As the computer assumes an increasing burden of managing instruction, so may it assume a greater share of the burden in improving instruction. The computer will force greater scientific analysis of the curriculum and will perhaps centralize decisions with respect to instructional methods and materials. Many decisions which classroom teachers formerly made regarding the scope and content of the curriculum and the choice

of instruction methods and materials may be preempted by central office personnel. It has been in these realms of decision making at the local classroom level that the supervisor has typically applied his art, which will now become increasingly obsolete. His other major function has typically been the diagnosis, evaluation, and remediation of instructional methodology. The computer will be able to gather a plethora of data on both student performance and teacher performance and will analyze the correlation of the two in a far more sophisticated and thorough manner than the human supervisor was ever able to do. The task of feeding back and interpreting these data to the teacher and the task of imposing quality control over the teacher will remain in someone's job description. Whether this quite limited function of what was formerly known as supervision will be assumed by the principal or by a smaller number of supervisors specializing in this function remains to be determined.

Counselors will undoubtedly remain and play an increasingly important part in the educational enterprise as the computer assembles, stores, analyzes, and disseminates a vastly increased volume of data on each student.

The future of teachers of special education is also uncertain. If, as several authorities on CAI suggest, all teachers will become increasingly occupied with remedial instruction for students who are rejected by the machines, then the present distinctions between special education teachers and regular classroom teachers may become increasingly obscured. It is probable, on the other hand, that educational technology will accommodate a vastly larger range of individual differences than the conventional classroom and that the number of student rejects from good CAI systems will be greatly reduced. There is evidence to suggest that many students who cannot or will not learn in conventional classes do much better in some of the newer instructional systems. Should this prove to be the case generally, it is possible that the load of special education teachers will be materially reduced but perhaps never completely eliminated.

Reshaping the Role of the Principal

Consider the role of the school principal in the new technological systems. The computer can already relieve the principal of much of the drudgery of his job: processing records, analyzing student achievement, formulating school schedules, assigning students to classes, forecasting school enrollments, monitoring the school budget, and accounting for finances, among others. The computer can perform these tasks far more swiftly and more reliably in most cases than the principal. By using computers more time is made available for the principal to fulfill his role as leader and educational planner.

Cybernation will undoubtedly have its greatest impact upon the principalship in the realm of educational decision making. In this discussion, distinction is made between the principal's participation in group decision making relative to the entire school system and his responsibility for making decisions for his school building. The current ethos with respect to the former is that, except for very large school systems, the principal should be a member of the administrative cabinet or council which, under the leadership of the superintendent, formulates many administrative decisions throughout the realm of the enterprise and shapes recommendations of educational policies for consideration by the board of education. This strategy has been justified in part because the superintendent may have been too far removed from the action to gather and weigh all of the relevant facts, to conceive and evaluate all possible alternatives, and to formulate decisions confidently alone. In other words, the application of many minds was thought to be essential to collecting and processing the data and to weighing and selecting the alternatives. Cybernation now permits the storage and analysis of far greater amounts of data as well as more swift and accurate formulation and assessment of alternatives. To be sure, value questions remain beyond the capability of the computer. But whether the value questions will be seen as sufficiently compelling to justify the far greater time and expense involved in group decision making is questionable.

Some predict that the computer and the systems manager may largely displace the principal in the major decision-making councils of the school systems. Regardless of whether this development would have a salubrious effect upon the quality of decision making (some would disagree), it is obvious that the displacement would lessen the prestige of the principalship. However, predictions of this variety fail to take into account the many intangibles that are part of high-level decision and beyond the modeling and programing capabilities of systems analysts. Computers may help administrators sharpen judgments but will not reduce the importance of judgments. Data processing guided by a defensible model may generate alternatives, but it will not do away with the significance of the human decision maker in the principalship.

Consider the possible effects of the computer on the principal's role in making decisions about the operaton of his building. Recently there has been a strong trend in educational thought, and to some degree in practice, toward the decentralization of decision making in the management of individual building units in school systems. This strategy has been defended on the grounds that this authority should (a) be as close to the information relative to the decision as possible, (b) be as close as possible to the people who must implement the deci-

sion, and (c) permit subordinates to exercise more creativity and adaptability. The computer now permits the collection, storage, and retrieval of information from local units in the central office and thereby abrogates the first requirement. Of course, printouts of the necessary information could also be transmitted to the principals' offices so that the first requirement is no longer a determinant. Whether instructional technology places more responsibility for implementing decisions at the central headquarters than it does at the building level and whether it will encourage creativity and flexibility remain to be seen. Argument can be made both ways. Therefore, the impact of cybernetics on decentralization or recentralization of decision making relative to individual schools is at present indeterminable. If industrial experience can provide an object lesson for education, the trend will probably be toward recentralization of administrative decision making. Most industries with computerized information systems have established huge centralized management centers which have preempted much of the decision making performed previously at the local plant level.

In any event, it is essential that fateful decisions about decentralization or centralization of administrative decisions in school systems be reached thoughtfully in terms of the welfare of the total enterprise. It may be tempting to permit considerations of administrative convenience or the logistics of the communication system to preempt concern of more compelling considerations. Should this happen, the role and responsibility of the principal might change in significant ways. In any event, in most school systems cybernation and systems theory will influence the principal's responsibilities as a manager of instructional resources. The computer, in conjunction with the application of systems theory, will probably relieve the principal of making decisions that control the actions of more and more individuals and will thereby reduce the number of principals required for a given enrollment. The primary consideration is, of course, not the unreasoned protection of any functionary's role and prestige but rather the application of that system of authority for decision making that contributes most to the accomplishment of the school system's goals.

It was suggested that the creative use of a wide variety of specialists will be demanded to make instructional technology work. This, in turn, will point to the increased importance of the coordination role of the principal. Making sure that the right specialist is available in the right place will be a major responsibility of the school executive at the attendance level. Synchronizing the efforts of men and machines to optimize learning opportunities for pupils will continue to be a challenge for most principals in the future, even though the relationship between men and machines may be changed dramatically.

Reshaping the Role of the Central Staff

Mention was made earlier of the probable appearance of new specializations in the administrative hierarchy: the systems analyst, the educational engineer, the coordinator of CAI, and others. The new specialists will probably preempt some of the authority presently exercised by supervisors, principals, and classroom teachers. They will be part of the new central staff team—a team the configuration of which will be quite different from its predecessor. We need not conclude before the fact that this *necessarily* will be bad.

Consider, for example, the differences in considerations between a school district's adoption of arithmetic textbooks and its adoption of a computer-managed instructional program in arithmetic. In the adoption of textbooks, it is perfectly feasible to delegate responsibility for a decision to committees composed of teachers, principals, and supervisors of arithmetic. It is conceivable that individual schools within the system might adopt different arithmetic series. In adopting a computer-managed instructional program in arithmetic, however, the locus of decision making changes. Important questions will arise concerning the logistics of the proposed innovations, compatibility of hardware and software, unit costs, comparative benefits, demands on computer time, scheduling, and so forth. Most of these considerations will be beyond the competence of the classroom teacher, the subject matter supervisor, and the principal. Although these persons may continue to be consulted with respect to pedagogical considerations of the software, they will not be able to challenge the educational engineer's judgments in the esoteric domain of his competency.

Other examples could be cited to suggest that the new educational technology specialists will preempt many of the former prerogatives of the principal, supervisor, and teacher. In so doing, the decision-making responsibility of the central office will be escalated while the decision-making responsibility of middle managers will be reduced. The degree to which this will prove true will depend to an extent on the narrowness of the specialization of these new central office personnel. If their specialization is narrow, they will manifest the phenomenon of "trained incapacity" to which Veblen called attention a generation ago. The amount of line responsibility written into the job descriptions of these new specialists will also be a factor. However, it is probable that their job descriptions will emerge from their capabilities and their behavior rather than the other way around. The level of sophistication and the commitments of the line administrators, particularly the superintendent, will be another determinant. A superintendent or principal who is not knowledgeable and confident in the deployment of new educational systems will probably delegate more responsibility to the

new specialists or will acquiesce in the specialists' reach for greater authority. As one writer observed, the systems approach at the top gives way to a vast morass of pushing and shoving—which is publicly cloaked as the refining of programs and procedures. Sometimes it is, but often it most definitely is not. Highly cybernated school systems will probably be characterized by more centralization of control and a reduction in the number of echelons in the administrative hierarchy.

Reshaping the Role of the Superintendent

The aspects of educational technology that have the greatest potential for redefining the role of the superintendent of schools are systems management theory, the revolution in information processing, and the emergence of new specializations. These related phenomena will have tremendous potential impact on the most fateful function of the administrator: decision making. By combining the discipline of systems management with the data processing capability of the computer, it is conceivable that the decision-making process in school administration may be revolutionized. Such a revolution would surely have considerable impact upon the role of the superintendent. The task of coordination of specialists will be greater at the superintendency level than at the principalship level.

Some forces vastly increase man's intellectual reach. Systems theory permits conceptualization of virtually the entire context of the world of school administration—the objectives, the resources, the required inputs, the constraints, the controllable variables, the various subsystems and their dynamic relationships, the complete range of alternative subsystems, their costs, their benefits, and the consequences for all of these factors of any change made in the total system. Systems theory yields the theoretical model that charts all of these relations and interactions. The computer provides the capacity for the collection, storage, retrieval, and analysis of much of the data which are relevant to any and all parts of the theoretical model. With its infallible memory, its unbelievable speed and accuracy, and its lack of bias, the computer is able to make detailed analyses in a few seconds that would take a team of administrators years to perform.

The electronic computer is perhaps the first creation of man that has demonstrated anything even remotely resembling human intelligence. Miraculously, some of the newer computers have built into them the capability of learning from their own mistakes, a capability that is not always built into their human counterparts. Computers are limited only by the creativity and wisdom of the programmers who command them; that is, the computers can do well only those things they are told to do. The computers of the twenty-first century, we are told, may be

capable of creative thought and of programing themselves eventually. Should this occur, will the administrator himself become Prometheus?

The prospect of this synthetic machine intelligence frightens some; they fear that the machine, which already surpasses man in memory, may eventually surpass him in creativity, reducing the administrator to an intolerably inferior role in an enterprise which he once controlled. Others believe that the machine can never be more creative than the man who creates it and that, *therefore,* it cannot supplant human intelligence or eliminate the crucial role of the administrator in the decision-making process. Nevertheless, the administrator and his social milieu, unlike the computer, are bound up in an inextricable network of feelings, emotions, values, tastes, needs, and motives that must impinge upon the decision-making process; these factors are inevitably beyond the domain of the computer.

For the foreseeable future at least, administration without the human administrator is practically inconceivable. Nonetheless, the potential impact of the computer on the work of school administration is formidable. Most important, it promises to bring a far greater degree of rationality to the decision-making process, certainly none too soon in the beleaguered world of school administration. Our hero may soon be liberated from his dependence on intuition, hunches, guesses, and biases in the decisions he faces daily. The computer will force him to think more objectively, to define his purposes more explicitly, and to examine the full range of alternatives more carefully. The superintendent will probably be forced to concentrate more effectively on long-range planning, policy making, and evaluation. We are told that the computer revolution will relieve top managers of their minor burdens and will increase enormously the pressures on them to come to grips with the moral and ethical consequences of their decisions. In the past, the administrator could claim that he had too little information to anticipate all of the consequences of all possible alternative decisions. The new computer capability will deprive tomorrow's administrator of this excuse.

Finally, the superintendent may discover that decisions and policies will emerge from the wisdom put into the systems theory by the systems analyst, the rationality of the data processing program put into the computer by the programmer, and the value judgments derived from the outcome by the superintendent. As noted earlier, this procedure probably will supplant his administrative council's consensus. Perhaps that group will be rendered much less important, although it undoubtedly will still function in making value judgments. Administration may then have come full circle from classical scientific management to democratic administration to behavioral administration to

computer-assisted classical management.

New Patterns of Development of Teacher and Students

At this juncture in history, one can comment only generally on the deployment of professional employees and students in a cybernetic educational system. Contemporary student-teacher ratios will rapidly become obsolete, but new ratios cannot be predicted because they will vary so much. For example, one might predict that a "computer-assisted" secondary school guidance counselor could deal effectively with more than his present 350 students if the computer handled all of the data processing, analysis, record keeping, and even some of the conferencing with students. On the other hand, the instantaneous availability of a vastly increased volume of data about each student may decrease his case load. With installation of mass media and multimedia instruction, along with computer-managed individual study, it is conceivable that classrooms may be replaced entirely by auditoriums, conference rooms, and individual study carrels. The impact of this new deployment of space on the deployment of teachers and students is apparent at once. Perhaps all that can be said is that the new patterns will be quite different from those of the present, varied within the school system and varied in time, and therefore not subject to generalized description.

New Attendance Unit and Administrative Unit Configurations

Educational technology is likely to have a profound effect on the organization of attendance units and administrative units. Current principles about optimum size of school buildings may become obsolete. With such innovations in communications as dial access to remote computers, the miniaturization of electronic equipment, the cybernation of instructional resources and perhaps even many pupil personnel services, neighborhood elementary schools of from 10 to 20 students housed in an apartment house or remodeled store may become very feasible. On the other hand, instructional systems requiring direct access to computers and mass media of communication might require attendance units of several thousand. Perhaps all that we can be sure of is that different instructional systems will require different sizes of attendance units or, as suggested later, perhaps no school buildings at all.

The enormous costs, at least at present, of electronic installations will probably require much larger administrative units to make pupil unit costs tolerable. Well-stocked instructional materials centers with supporting hardware will represent enormous expenditures that can be justified only by high volume of utilization and therefore large administrative units. An alter-

native would be interdistrict compacts for time-sharing of computers and cooperative purchase and use of facilities and perhaps certain personnel on a regional basis.

Will the School Itself Survive?

We come now to the most profound question of the entire discussion: Will the school as a formal institution disappear in a new era of totally cybernetic education? This query may not be as fanciful or irresponsible as it seems. One of the more knowledgeable observers of the new educational technology believes that, by combining mass instructional technology with individual instructional technology, it would be technically possible (but prohibitively expensive for some time) to eliminate not only the teacher but also the entire school system. According to some, totally automated education may be achievable almost immediately.

Our own powers of forecasting may not equal those of Wells, Orwell, or Huxley, but let us nevertheless examine the various components of educational technology that are either operational or nearly so at the moment to see how a totally automated educational system might appear.

Consider each student of school age having at his disposal a television receiver, either in his home or in a publicly supported neighborhood center. Assume also that each student has available a dial-access facility which permits him access, via laser, to a central learning resource center equipped with a large, high-speed computer plugged into a library of televised, programed, recorded, and printed materials serving whole cities or regions. By using microwave communication via orbiting satellites, the student could have access to any knowledge that is programed into any learning resource center anywhere in the world.

Assume also that each student has a light-pen and a teletypewriter which permit him to feed back to the computer his responses to questions posed by the program and to ask questions of the computer. (Eventually, the student and the computer will communicate through spoken language.) The computer records and analyzes the student's responses to determine whether he is ready for the next learning step or whether he should be sent along a branched program uniquely designed to remedy his particular difficulty with the task at hand. When the student is ready to stop, he signs off and the computer dutifully remembers the point at which the student must begin when he signs in again.

Data on the quality of each student's performance could be researched for the continual refinement of the program. Data on student performance could be monitored to assure that each student was putting sufficient effort into his learning. Essential pupil personnel services that cannot be automated could be

given by human agents in home visitation. If the child moved to another community, a complete printout of his entire academic record and biographical data could be provided in seconds for the computer at the learning resource center in his new community.

Through the miracle of miniaturization, all of the equipment at the student's home terminal could be packed into a suitcase.

The cost of this technology is, of course, a crucial consideration. As pointed out in another chapter, the cost of even much less fanciful installations is still prohibitively expensive for most districts.

It is conceivable that the student's cognitive development might be handled as effectively, perhaps more effectively, through this fully automated educational environment at home as it could be in conventional schools. Whether the student's affective and psychomotor development could be equally well developed in this environment is, of course, another matter. Any reasonably complete view of education is concerned with social, emotional, physical, moral, and aesthetic as well as intellectual growth. Clearly a completely automated educational environment cannot provide the social interaction essential for the refinement of one's interpersonal relations, self-understanding, values, tastes, feelings, and physical and mental health—a refinement which is essential to the well-educated student.

Some will regard this Orwellian possibility, the elimination of the formal public school, which Horace Mann regarded as "the greatest discovery made by man," as the final conquest of the machine in its historic struggle with man. Others may regard it as the ultimate triumph of man over the machine in the liberation of the educative process from the constraints of time and space.

In Sum

In this chapter we have speculated about the impact of the new instructional technology in shaping education in the future. We have examined its possible impact on the role of the teacher, the instructional specialists, the principal, the superintendent, the deployment of staff and students, the attendance and administrative units. Finally we have speculated a bit on the destiny of the school itself as a formal institution.

These speculations, no doubt, will titillate the fancy of the scientists and trouble the souls of the humanists. We implore the thoughtful educator to neither accept nor reject a priori speculations about the future, but to ask rather that both the technological innovations and the conventional instructional systems which they may replace be appraised experimentally and that the benefits of each be measured against the objectives we hold for education. We implore that judgment not be

contaminated either by passion for novelty or by an unreasoned commitment to the conventional. We suggest that now is the time to begin the necessary planning for smooth transition into the age when technology is harnessed (rather than grafted) to the purposes of instruction.

Footnotes

1. Commission on Instructional Technology. *To Improve Learning.* A Report to the President and the Congress of the United States. Washington, D.C.: Government Printing Office, 1970. p. 20.
2. *Ibid.*, p. 55.
3. Joyce, Bruce R. *The Teacher and His Staff: Man, Media, and Machines.* Washington, D.C.: National Education Association, 1967. 28 pp.
4 Commission on Instructional Technology, *op. cit.*, p. 57.

The American Association of School Administrators